ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

DRAFT

Site Physical Characteristics Summary Report

Rocky Flats Environmental Technology Site

10808 Highway 93

Golden, CO 80403-8200

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ACRONYMS

ac-ft	acre-feet
BZ	Buffer Zone
C	Celsius
CCP	Comprehensive Conservation Plan
CDOW	Colorado Division of Wildlife
cfs	cubic feet per second
CFR	Code of Federal Regulations
CHWA	Colorado Hazardous Waste Act
cm	centimeter
cm/sec	centimeters per second
CNHP	Colorado Natural Heritage Program
CRA	Comprehensive Risk Assessment
CRMP	Cultural Resource Management Plan
CSU	Colorado State University
DOE	U.S. Department of Energy
DRCOG	Denver Regional Council of Governments
ESA	Endangered Species Act
ESCO	ESCO Associates Inc.
ET	evapotranspiration
F	Fahrenheit
FWS	U.S. Fish and Wildlife Service
g	acceleration due to gravity
GMU	Game Management Unit
HAER	Historic American Engineering Record
IA	Industrial Area
K-H	Kaiser-Hill Company, L.L.C.
LHSU	lower hydrostratigraphic unit
m	meter
mph	miles per hour
m/s	meters per second
MSL	mean sea level
N/A	not applicable
NHPA	National Historic Preservation Act
NPL	National Priorities List
OU	Operable Unit
P.L.	Public Law
PMJM	Preble's Meadow Jumping Mouse
RCRA	Resource Conservation and Recovery Act
RFA	Rocky Flats Alluvium
RFETS	Rocky Flats Environmental Technology Site
RFI/CMS	RCRA Facility Investigation/Corrective Measures Study
RFPO	Rocky Flats Project Office

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RI/FS	Remedial Investigation/Feasibility Study
SHPO	State Historic Preservation Office
SCS	Soil Conservation Service
SID	South Interceptor Ditch
UDFCD	Urban Drainage and Flood Control District
UHSU	upper hydrostratigraphic unit
U.S.C.	U.S. Code
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VFA	Valley Fill Alluvium
WQCC	Water Quality Control Commission

1.0 INTRODUCTION

This Site Physical Characteristics Summary Report has been prepared in accordance with Task 7 of the *Final Work Plan for the Development of the Remedial Investigation and Feasibility Study Report* (DOE 2002). This report provides a summary of the physical characteristics of the Rocky Flats Environmental Technology Site (RFETS), including surface features, subsurface features, geology, soil, the vadose zone, surface water hydrology, hydrogeology, meteorology, demographics and land use, and ecology. This Summary Report will be incorporated as Section 2.0 of the Draft Remedial Investigation/ Feasibility Study (RI/FS) Report.[1]

The study area in this report includes the Industrial Area (IA) and Buffer Zone (BZ) Operable Units (OUs) at RFETS. The study area also includes areas adjacent to RFETS, depending upon the specific characteristic being evaluated. Historically, the terms "RFETS" and "Site" have been used to denote both the RFETS property and the geographic extent of the National Priorities List (NPL) Site. In this report, "Site" refers to the area defined for the NPL, and "RFETS" or "site" refers to the property owned by the United States government.

Under the Rocky Flats National Wildlife Refuge Act of 2001 (P.L. 107-107, Subtitle F, 16 U.S.C. 668dd) (Refuge Act), future ownership and management of RFETS shall be retained by the United States. Under the Refuge Act, RFETS will become the Rocky Flats National Wildlife Refuge (Refuge) after remediation and closure of RFETS is completed by the U.S. Department of Energy (DOE). The Secretary of Energy will transfer administrative jurisdiction over certain RFETS land to the Secretary of the Interior, and management responsibility for those areas will be transferred to the U.S. Fish and Wildlife Service (FWS).

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[1] Because remedial activities at RFETS are also being conducted under the Resource Conservation and Recovery Act (RCRA) and the Colorado Hazardous Waste Act (CHWA), the RI/FS Report will satisfy the RCRA/CHWA requirements for a RCRA Facility Investigation/Corrective Measures Study (RFI/CMS) Report. For simplicity, the report is referred to as the RI/FS Report.

Information presented in this Physical Characteristics Summary Report is provided to help characterize the physical features at RFETS to support the analysis and design of potential response actions evaluated in the RI/FS Detailed Analysis of Alternatives. The Detailed Analysis of Alternatives will be incorporated into the Draft RI/FS as Section 7.0, and will be prepared under Task 14 of the RI/FS Work Plan.

2.0 SURFACE FEATURES

RFETS is located approximately 16 miles northwest of Denver, Colorado, and approximately 10 miles south of Boulder, Colorado (Figure 1). RFETS occupies approximately 10 square miles in Sections 1 through 4 and 9 through 15 of Township 2 South, Range 70 West, 6th Principal Meridian. To the north, RFETS is generally bounded by State Highway 128. To the east is Jefferson County Highway 17, also known as Indiana Street; to the south are agricultural and industrial properties and State Highway 72; and to the west is State Highway 93. In addition, a spur of the Southern Pacific Railroad runs to the western boundary of RFETS.

The site is located at the interface of the Great Plains and Rocky Mountains. Approximately two miles west of the RFETS western boundary, the foothills of the Front Range rise sharply above the lower elevations of the plains. The higher elevation areas west of RFETS are characterized by rugged terrain and relatively sparse human population. In contrast, the plains east of RFETS are characterized by relatively gentle topography and higher population density associated with the greater Denver metropolitan area.

The western portion of RFETS is located on a broad, relatively flat pediment that slopes eastward from the foothills. The pediment is capped by unconsolidated surficial deposits. On the eastern portion of RFETS, the pediment surface is dissected by stream valleys that trend generally from west to east. The valleys cut into the underlying bedrock in some locations, although in most places bedrock is located beneath colluvium that has collected along the valley slopes. Elevations at RFETS range from approximately 6,190 feet above mean sea level (MSL) on the western portion of the pediment to approximately 5,600 feet above MSL in the southeastern corner of the site.

The primary topographic features at RFETS are the Rock Creek, Walnut Creek, and Woman Creek drainages that traverse the site and flow generally from west to east (Figure 2). Sixteen named retention ponds exist throughout RFETS, not including several smaller, unnamed ponds. These include nine ponds on North and South Walnut Creeks, two ponds in the Woman Creek drainage, one pond downgradient from the site of the Present Landfill, two ponds in the Rock Creek drainage, and two ponds on Smart Ditch. In addition to the ponds, other manmade surface water features at RFETS include several drainage ditches that cross the site, including the South Interceptor Ditch (SID), McKay Ditch, Upper Church Ditch, and Smart Ditch (see Section 5.0).

RFETS is vegetated with five general plant communities. These include the mixed mesic grassland and xeric tallgrass prairie, which are the dominant plant communities. Wetlands, riparian woodlands, and tall upland shrublands are less dominant plant communities. A detailed discussion of the various plant communities is provided in Section 9.1.

Site accelerated remedial actions resulted in removal of all buildings, except for the former east and west vehicle inspection sheds, which will be retained for Refuge management uses. Other site activities resulted in some surface recontouring and revegetation of the former IA, after removal of parking lots and other surface infrastructure features, as necessary. In addition, ditches, stormwater conveyances, and selected ponds have been eliminated or reconfigured to meet objectives for slope stability and stormwater flow, and all pavement has been removed. This work was generally guided by the Land Configuration drawings (K-H 2004a) and the Environmental Assessment, Pond and Land Configuration DOE/EA – 1492 (DOE 2004). RFETS surface features are displayed on Figure 2.

Other manmade features of the site include protective covers constructed at two landfills, the Original Landfill and Present Landfill, which were used for historic site operations. The Original Landfill, located in the southwestern corner of the IA OU, has a soil cover layer with a minimum thickness of two feet. The soil cover is engineered to promote surface water runoff while minimizing erosion, reduce surface water ponding, increase overall slope stability, and provide for suitable vegetation (K-H 2004b). At the Present Landfill, located north of the IA OU, a cover was constructed to comply with requirements of the Resource Conservation and Recovery Act (RCRA) for minimizing infiltration and erosion. The Present Landfill cover consists of a soil cover, geosynthetic clay liner, flexible membrane liner, geocomposite drainage layer, cushion layer, cobble layer, and soil cover layer (K-H 2004c). In addition, although not required to achieve RCRA performance standards, a reasonable effort to reestablish vegetation was undertaken to reduce erosion, and minimize intrusion of noxious weeds and burrowing animals.

With respect to surface features associated with use of the site as a Refuge, the action proposed in the Rocky Flats National Wildlife Refuge Final Comprehensive Conservation Plan and Environmental Impact Statement will involve limited developed features for long-term use. These features will include approximately 16 miles of trails, a seasonally staffed visitor contact station, trailheads with parking, and developed overlooks (FWS 2004a).

Several public utility corridors have historically been located within the site boundaries, including low- and high-pressure natural gas pipelines, electric transmission lines, and telecommunication lines. These utilities are expected to remain as long as the utility easement or right-of-way is needed. Figure 3 presents a map of existing utility easements. The Refuge Act provides that a future easement is authorized for possible widening of Indiana Street along the eastern RFETS boundary. Otherwise, new easements are prohibited by the Refuge Act.

3.0 SUBSURFACE FEATURES

This section addresses subsurface features that will remain following the accelerated actions - it needs to be expanded and reviewed for accuracy/completeness.

Between the ground surface and three feet below grade, essentially all structures have been removed, with the exception of utility lines less than two inches in diameter and three groundwater collection and treatment systems that serve an ongoing function. These systems are listed below and are shown on Figure 4:

- Solar Ponds Plume Treatment System;
- Mound Site Plume Treatment System; and
- East Trenches Plume Treatment System.

At depths greater than three feet below grade, some subsurface structures remain in place. These include building basement structures and utility structures such as sanitary sewer and process waste lines.. As part of the accelerated remedial action, these lines were characterized, flushed (in the case of sanitary sewer lines), and either breached or plugged. Manmade subsurface features that remain are listed in Table 1 and shown on Figure 4.

4.0 GEOLOGY

RFETS is situated approximately two miles east of the Front Range of Colorado on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province (Spencer, 1961). The geologic history of the Colorado Rocky Mountain region, which includes the site area, has been summarized by Haun and Kent (1965). Several comprehensive site-specific studies have been undertaken to characterize the local geology and hydrogeology at RFETS (Hurr, 1976; EG&G 1991, 1995a, 1995b). In addition, a large amount of lithologic and stratigraphic information has been obtained for RFETS from multiple sources. These include interpretation of aerial photographs, field geologic mapping, coal and aggregate mine development, petroleum exploration, and the completion of approximately 2,000 on-site boreholes and monitoring wells. A brief summary of results from historic investigations is presented in the following sections.

4.1 Stratigraphy

The stratigraphic sequence that underlies the site extends in age from the crystalline Precambrian gneiss, schist, and granitoids at 3,000 feet below MSL to the unconsolidated

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Quaternary deposits at the surface approximately 6,000 feet above MSL. The generalized lithologic section in the Rocky Flats area is shown on Figure 5 (Leroy and Weimer 1971).

The Pierre Shale and Fox Hills Sandstone underlie the site, with the latter exposed in quarries along the western edge of the site. The Laramie and Arapahoe Formations are exposed at the surface or underlie the site. Unconsolidated surficial deposits (for example, the Rocky Flats Alluvium [RFA] and the Verdos terrace alluvium) unconformably overlie bedrock. The unconsolidated surficial deposits, combined with the weathered portion of subcropping bedrock formations, form the upper hydrostratigraphic unit (UHSU).[2] Because of the wide extent of unconsolidated surficial materials beneath the IA and eastern BZ OUs, and relatively high hydraulic conductivity compared to weathered claystone, the UHSU has the greatest influence on groundwater flow and contaminant transport at the site.

4.2 Unconsolidated Surficial Deposits

Based on local mapping (Hurr 1976; EG&G 1995a; USGS 1996), the unconsolidated surficial deposits that cover the pediment and adjacent watersheds proximal to the IA OU consist of the RFA, Valley Fill Alluvium (VFA), and colluvium that unconformably overlie bedrock. Various other younger unconsolidated alluvial deposits, such as the Piney Creek Alluvium (EG&G, 1995a and USGS, 1996), occur topographically below the RFA in the RFETS drainages. In addition, artificial fill material is found locally throughout the IA OU, and landslide and slump deposits are common on slopes in the BZ OU (EG&G 1995a) (Figure 6). The surface geology at RFETS is shown on Figure 7.

[2] Pursuant to Colorado Water Quality Control Regulation 42.5(7), the UHSU is the uppermost layer of groundwater incorporating any aquifer or other zone of groundwater occurrence that is first encountered beneath the ground surface and includes all saturated geologic formations, unconsolidated alluvium and colluvium, and hydraulically connected zones in bedrock. Pursuant to Colorado Water Quality Control Regulation 42.7(1)(a) the UHSU includes the unconsolidated Quarternary and RFA, colluvium and VFA, and weathered claystone and hydraulically connected sandstone bedrock of the Arapahoe and Upper Laramie Formations.

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4.2.1 Rocky Flats Alluvium

The youngest areally-extensive stratigraphic unit at RFETS is the early Pleistocene RFA. The RFA was deposited by intermittent braided streams and debris flows. Deposition took place on the pediment within a coalescing alluvial fan/braided stream system. Coarse gravel and cobbles were most likely deposited in channels by debris flows. Sand and fine gravel were deposited in channels and along banks, forming natural levees, while silt and clay would commonly be found on floodplains. The RFA occurs above the erosional bedrock surface and consists of generally poorly sorted, poorly stratified gravel, sand, cobbles, silt, and clay. The thickness of the RFA decreases from west to east, and ranges from slightly more than 100 feet to less than 10 feet. This is particularly important in the eastern IA and BZ OUs where the RFA is thinner or non-existent. In those areas, the UHSU groundwater flows through weathered bedrock, instead of the RFA, and therefore moves at a much slower velocity compared with RFA flow.

The coarse clastic materials (boulders and cobbles) were derived primarily from the Precambrian igneous and metamorphic rocks that crop out in Coal Creek Canyon, approximately 2 miles west of RFETS. Less common source rocks are the steeply eastward-dipping sedimentary formations exposed at the mouth of Coal Creek Canyon. In a few locations, the pediment surface beneath the RFA has been eroded, exposing the Arapahoe Formation and/or the Laramie Formation.

4.2.2 Colluvium

Colluvium occurs on the hillslopes descending into drainages at RFETS. This material is derived from the RFA and underlying weathered bedrock, and has a hydraulic conductivity that ranges between the hydraulic conductivities of the RFA and weathered bedrock. Colluvial material consists of unconsolidated clay with silty clay, sandy clay, and gravel layers. Occasional dark-yellowish-orange iron staining is present in colluvium consisting of reworked bedrock.

4.2.3 Landslide and Slump Deposits

Landslide and slump deposits have been identified in nearly all of the drainages at RFETS (EG&G 1995a; USGS 1996). These occur primarily in the upper bedrock claystones and involve downward and outward movement along rotational slip planes. At RFETS, landslides and slumps are recognized by a curved scarp at the top, a coherent mass of material downslope that has been rotated back toward the slip plane, and hummocky topography at the base. Older, weathered landslide and slump deposits are expressed in weakly consolidated, grass-covered slopes as bulges or low wavelike swells (EG&G 1995a; USGS 1996). Several distinct landslide and bedrock slump-blocks have been mapped above and along the banks of Walnut and Woman Creeks (EG&G 1995a; USGS 1996) (Figure 7). These deposits can be up to 35 feet thick but are generally relatively shallow.

4.2.4 Valley Fill Alluvium

VFA occurs in all the major drainages at RFETS and consists of unconsolidated, poorly sorted sand, gravel, and pebbles in a silty clay matrix. Shroba and Carrara recognized two stages of VFA: Piney Creek and Post-Piney Creek Alluvium (USGS 1996). The Piney Creek Alluvium forms low terraces appproximately three to six feet above modern stream level, and contains calcium carbonate veinlets and locally one or more buried soil horizons. The Post-Piney Creek Alluvium forms modern stream channels and floodplains, and does not contain secondary calcium carbonate.

4.2.5 Caliche

Local intervals of the unconsolidated surficial deposits may contain caliche, ranging from 25 to 80 percent. Caliche, which is generally calcium carbonate but may consist of magnesium carbonate, silica, or gypsum, forms by evaporation of vadose zone water. Early stages of caliche formation may produce either a powdery granular calcite or development of indurated nodules, termed "calcrete" (Blatt et al. 1980).

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4.3 Bedrock Deposits

An unconformity, representing a depositional hiatus of greater than 60 million years, separates the Arapahoe and Laramie Formations from the overlying unconsolidated surficial deposits. The unconformity comprises the irregular, undulating surface of the pediment, controlled in part by stream erosion/incision and subsequent deposition of the RFA. Incised channels in the bedrock surface represent important local preferential groundwater flow paths (EG&G 1995b).

4.3.1 Arapahoe Formation

The Arapahoe Formation is mainly composed of claystone and silty claystone, with lenticular sandstone bodies in the basal portion of the formation, and is generally less than 50 feet thick at RFETS (EG&G 1995a). The depth of the contact between the Arapahoe Formation and the underlying Laramie Formation is generally less than 100 feet below ground surface in the RFETS area. In many areas the Arapahoe Formation is entirely absent, having been removed by erosion.

4.3.1.1 Arapahoe Sandstones

The basal sandstones in the Arapahoe Formation (referred to as the No. 1 Sandstone) are poorly to moderately sorted, subangular to subrounded, clayey, silty, very fine-grained to medium-grained, and lenticular in geometry. Trough and planar cross-stratification are common sedimentary structures contained in these sandstones (EG&G 1991; EG&G 1995a). The depositional environment of the Arapahoe Formation has been interpreted as a subaerial fluvial system with associated channel, bar, and floodplain deposits (EG&G 1995a).

The sandstones are generally weathered to a depth of 30 to 40 feet below the base of the RFA. The weathered sandstone varies from pale orange to yellowish-gray and dark yellowish-orange in color. Unweathered sandstones are light to olive gray. Fractures have been noted in the weathered zone at depths of 5 to 14 feet. Arapahoe sandstones comprise an important element of the groundwater flow regime at RFETS, and represent a relatively higher-velocity groundwater pathway in the UHSU (EG&G 1995b).

4.3.1.2 Arapahoe Claystones/Silty Claystones

The Arapahoe Formation claystones and silty claystones are massive and blocky, and may contain thin laminae and stringers of sandstone, siltstone, and coal. The weathered claystones can extend to approximately 30 feet below the base of the RFA and, in some cases, farther. Weathered claystones range in color from pale yellowish-brown to light olive gray and are moderately stained with iron oxides. Unweathered claystones are typically dark gray to yellowish-gray.

Fractures have been encountered between 6 and 26 feet in depth in Arapahoe Formation claystones and are associated with ironstone concretions and calcareous deposits in the weathered zone. Small vertical, horizontal, and 45-degree fractures have been encountered in the unweathered zone at depths of 30 feet to over 100 feet. Many of the shallower fractures are stained with iron oxide or calcareous deposits, suggesting groundwater movement (Rockwell 1988). Additional information regarding fracturing within the Arapahoe Formation is provided in White Paper: Analysis of Vertical Contaminant Migration Potential (RMRS 1996).

4.3.2 Laramie Formation

The upper contact of the Laramie Formation generally occurs at a depth of approximately 100 feet below the RFETS ground surface. However, in locations where the RFA is thin and the Arapahoe Formation is absent, the depth to the Laramie Formation is much less. The Laramie Formation is divided into two intervals: (1) an upper claystone unit, and (2) a lower unit composed of sandstone, siltstone, and claystone with coal layers (Weimer, 1973). The upper unit is estimated to be approximately 460 feet thick at some locations at the site and consists of light- to medium-gray kaolinitic claystones with few, dark-gray to black carbonaceous claystones. The lower unit, estimated to be approximately 285 feet thick, consists of coal beds and sandstones (Weimer, 1973).

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4.4 Structure

The site is located on the western flank of the Denver Basin, with the RFETS western boundary located approximately two miles east of steeply dipping strata on the eastern flank of the Front Range uplift. The Denver Basin is a north-south-trending, asymmetrical basin with a steep western flank and shallow eastern flank. The basin is more than 13,000 feet deep at its deepest point and contains bedrock of Paleozoic, Mesozoic, and Cenozoic age.

Subsidence of large basins and the uplift of the Front Range dominate the tectonic framework of the southern Rocky Mountain region. These uplifts occurred because of regional compression related to southwesterly movement of the North American plate over a gently dipping sequence of marine sediments.

4.5 Seismic Conditions

The Site-Wide Geologic Characterization Report for RFETS (EG&G 1995a) identified shallow bedrock faults near or within the IA OU, as shown on Figure 8. These faults, which trend north-northeast, were identified through estimated offset along a unique Laramie-aged claystone marker bed. None of these faults are known to extend into or offset the overlying RFA or Verdos Alluvium and evaluation of geologic and topographic features does not indicate recent movement has occurred along these faults. Consequently, the site is in a zone of relatively low seismic activity. Based on U.S. Geological Survey (USGS) general maps of peak horizontal bedrock acceleration, RFETS is located in an area with a 2-percent chance of exceeding, in 50 years, a peak bedrock acceleration equivalent to 0.12 the acceleration due to gravity (g) (USGS 2002).

Other faults have been inferred at the site, but not extensively characterized, based on lineaments and other structures found during drilling and excavation. These features are also confined to bedrock formations and do not appear to be active.

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4.6 Geomorphology

The dominant geomorphic processes at RFETS currently include side-slope erosion and the erosional activity of Walnut and Woman Creeks. The drainages erode and convey sediment, and are the primary forces that develop the slopes in the valleys. Slope erosion occurs as a result of precipitation while some movement of slope soils results from mass wasting, as occurs with landslides and slumps. Stream erosion occurs primarily by channel incision and headward erosion (active elongation of stream profiles by eroding the upstream end) as channels advance upstream.

North and South Walnut Creeks are at a relatively immature stage of development. These drainages have fairly steep, V-shaped cross-sections, and narrow floodplains characteristic of relatively immature geomorphologic development. Streams at this stage of development move relatively large quantities of sediment, particularly during heavy precipitation events, by eroding their channels through stream downcutting. In addition to downcutting their channels, the stream channels exhibit headward erosion. Alternately, Woman Creek has a more U-shaped cross-section and a broader floodplain compared to North and South Walnut Creeks, thereby suggesting a more mature stage of development. Less channel erosion likely occurs in the Woman Creek drainage.

Slumps and slides (including rotational failures) have developed on the hillslopes of Woman and Walnut Creeks in areas where shallow groundwater has saturated the unconsolidated material and weathered bedrock (Figure 7). The saturated condition causes an increase in soil pore pressure and reduces the soil shear strength until the slope fails. Slumps also occur in locations where the stream flow has undercut the base or toe of the slope.

4.7 Soils

RFETS soils form a pattern related to geologic parent materials, geomorphic landforms, relief, natural vegetation, and climate processes. The U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) developed map-unit models based on aerial photographs to reasonably predict the types of soils in an area. The boundaries of the

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map units were refined and the map-unit models were tested by digging test pits and recording the characteristics of the soil profiles studied (EG&G 1995c).

Soils are taxonomically classified based on specific soil properties (for example, number and size of clasts, particle-size distribution, acidity, distribution of plant roots, and structure of soil aggregates) and the arrangement of horizons within the soil profile. Figure 9 illustrates the SCS map units for RFETS defined at the soil-series level. There are four general SCS soil types at RFETS, associated with the geologic map units, as follows:

- Pediment (flat upland area) soils are located on the broad, dissected, eastward-sloping pediment surface in the western portion of the site. These soils are associated with the RFA geologic map unit.
- Valley-slope soils are located in the stream-cut valleys of the intermittent Rock Creek, Walnut Creek, and Woman Creek drainages. These soils are associated with the Laramie Formation, Arapahoe Formation, and landslide geologic map units.
- Hilltop soils of the eastern third of RFETS are similar to valley-slope soils and are associated with the Laramie and Arapahoe Formations. Localized areas on hill summits are associated with Terrace Alluvium.
- Drainage-bottom soils are forming in recent alluvium along drainage bottoms.

A comparison between the geologic map (Figure 7) and the soils map (Figure 9) illustrates the relationship between soils at the soil-series level and geologic map units. Specific geotechnical properties of the various soil types located within and around RFETS are described in Table 2.

5.0 SURFACE WATER HYDROLOGY

Streams and seeps at RFETS are largely ephemeral or intermittent, with stream reaches gaining or losing flow, depending on the season and precipitation amounts. Surface

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water flow across RFETS is primarily from west to east, with four drainages traversing the site (Figure 10):

- Rock Creek – Major drainage in the northwestern part of RFETS (does not receive runoff from the IA OU);
- Walnut Creek – Major drainage in the north-central portion of RFETS, including the majority of the IA OU;
- Woman Creek – Major drainage on the southern side of RFETS, including the southern portion of the IA OU; and
- Smart Ditch – Minor drainage in the far southern section of RFETS (does not receive runoff from the IA OU).

Even the largest drainages at RFETS typically have defined channels that are relatively narrow, ranging in bottom widths from two to ten feet. The channel bottoms intermittently vary between vegetation and exposed sediments and cobbles. Vegetation near the intermittent streams is dominated by riparian woodland/shrubland community types, with wet meadow and marsh species near seeps and ponds (see Section 9.1 for further discussion on vegetation).

A detailed discussion of each of the drainages is provided in Sections 5.1 through 0. Information is included on water routing, water volumes, peak flow rates, retention ponds, other structures, and a general description of the watershed. Drainages are discussed in order from north to south.

5.1 Rock Creek

The Rock Creek drainage covers the northwestern portion of the BZ OU (Figure 10). The Rock Creek watershed does not receive runoff from the IA OU. The watershed area is approximately 1,499 acres (as measured by gaging station GS04 [Figure 10]), and includes an area west of the RFETS boundary. Rock Creek is classified as stream

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segment 8 in the Boulder Creek basin by the Colorado Water Quality Control Commission (WQCC).

The Rock Creek drainage basin is characterized by east-sloping alluvial plains to the west, several small ponds within the creek bed, and multiple steep gullies and stream channels to the east. Flow in Rock Creek is ephemeral. The hydrology of the Rock Creek drainage is not expected to change as a result of accelerated remedial actions.

The mean annual discharge volume in Rock Creek, measured at gaging station GS04, is approximately 241 acre-feet (ac-ft) per year (based on flow records from October 1, 1996 through September 30, 2004). The peak flow rate measured at GS04 during the same period is 35.4 cubic feet per second (cfs). These flow data are summarized, along with flow data for other RFETS locations, in Table 3.

5.2 Walnut Creek

The Walnut Creek drainage comprises the central third of RFETS, and receives runoff from the majority of the IA OU, as well as the northeast BZ. The area of the Walnut Creek watershed upstream from gaging station GS03 is approximately 1,878 acres. The Walnut Creek basin includes several current or former tributaries within the RFETS boundaries, including, from north to south, McKay Ditch (formerly a tributary of Walnut Creek), No Name Gulch, North Walnut Creek, and South Walnut Creek. Descriptions of these sub-basins, and the off-site flow of Walnut Creek, are provided in Sections 5.2.1 through 5.2.6.

5.2.1 McKay Ditch

The McKay Ditch runs west to east across the northern BZ OU, and is hydrologically isolated from the IA OU. The ditch was formerly a tributary to Walnut Creek within the RFETS boundaries. However, in 1999, an underground pipeline was constructed in the northeast BZ OU to reroute McKay Ditch water and prevent it from commingling with water in Walnut Creek discharged from the RFETS retention ponds. This configuration allows the City of Broomfield to divert water from Coal Creek or the South Boulder

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Diversion Canal (both west of RFETS). The diverted water flows into the open-channel McKay Ditch and McKay Bypass Canal, across the northern RFETS BZ OU, and into the underground pipeline that runs eastward for approximately 3,500 feet on site before being routed underneath Indiana Street. On the eastern side of Indiana Street, the pipeline daylights and the water flows directly to Great Western Reservoir, where the water is stored by the City of Broomfield for irrigation purposes. The McKay Ditch is classified as stream segment 4a in the Big Dry Creek basin by the Colorado WQCC (Figure 11).

The McKay Ditch and Bypass Canal have a combined length of approximately 3.5 miles on RFETS property. The channel lining alternates between grass and exposed cobbles, and has grade-control structures constructed from rock and spaced intermittently. Water is diverted out of the McKay Ditch by a concrete diversion wall into a catch basin, and then into the diversion pipeline. The pipeline is approximately 3,500 feet long, ranges in diameter from 42 to 48 inches (high-density polyethylene pipe), and has a capacity of 110 cfs. Flows in excess of 110 cfs run over the diversion wall and into the McKay Ditch drainage downstream. To support downstream wildlife habitat, a one-inch-diameter opening exists in the diversion wall near its base. The small opening is designed to provide a stream of water, when water is flowing in the McKay Ditch, to supply the habitat in the McKay Ditch drainage downstream of the diversion structure.

The McKay Ditch is generally dry. Flows in the ditch historically occur in the spring, when the City of Broomfield water rights are exercised and water is diverted into the ditch, or when overland runoff is captured and transported by the ditch. Future flows in the McKay Ditch are expected to be similar to past flows given that site activities do not impact the configuration of the ditch, and operations are managed by the City of Broomfield.

The mean annual discharge volume in the McKay Ditch, measured at gaging station GS35 (downstream from the diversion to the pipeline), is approximately 69 ac-ft per year. The discharge volume for the ditch is based on flow records collected from October 1, 1997 through September 30, 2004. The peak flow rate measured during the same period

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is 23.6 cfs. These flow data are summarized, along with flow data for other RFETS locations, in Table 3.

5.2.2 No Name Gulch

No Name Gulch is located in the north BZ OU downstream from the East Landfill Pond. The East Landfill Pond receives runoff from the former Present Landfill area and the watershed immediately surrounding the pond, and is hydrologically isolated from the IA OU. A summary of the East Landfill Pond dam and pond characteristics and the pond operating protocol is provided in Table 4.

No Name Gulch is ephemeral, with periodic runoff occurring most frequently in the spring. The closure of the former Present Landfill, with a RCRA-compliant cover constructed over the landfill area, is expected to generate additional runoff compared to the historic runoff pattern. Drainage ditches along the perimeter of the Present Landfill cover allow free drainage of the geosynthetic composite cover and drainage layer, and direct surface water away from the landfill and into No Name Gulch. These ditches are generally lined with vegetation, or riprap in areas with steeper slopes that are more prone to erosion (K-H 2004c).

The mean annual discharge volume in No Name Gulch, measured at gaging station GS33, is approximately 17 ac-ft per year (based on flow records from October 1, 1997 to September 30, 2004. The peak flow rate measured during the same period is 6.8 cfs. These flow data are summarized, along with flow data for other RFETS locations, in Table 3. As discussed previously, No Name Gulch will receive increased runoff compared to that observed historically as a result of additional flow routed through the drainage ditches along the perimeter of the Present Landfill (K-H 2004c).

5.2.3 North Walnut Creek

Runoff from the northern portion of the IA OU flows into North Walnut Creek, which has four retention ponds (Ponds A-1, A-2, A-3, and A-4). A summary description of the dams, flow routing, and pond operating protocol in North Walnut Creek is provided in

Table 4. North Walnut Creek upstream from Pond A-4 is classified as stream segment 5 in the Big Dry Creek basin by the Colorado WQCC; downstream from Pond A-4, North Walnut Creek is classified as stream segment 4b.

In contrast to the majority of other site drainages, North Walnut Creek has continuous flow (as measured at gaging station SW093, located immediately northeast and downstream from the IA OU). The hydrology of the North Walnut Creek drainage following accelerated remedial actions is expected to differ from the hydrology when the IA existed. Removal of buildings and pavement from the IA significantly reduces the volumes and peak discharge rates of runoff.

When buildings and pavement existed in the IA, the mean annual discharge volume from North Walnut Creek, measured at gaging station SW093 (upstream from Pond A-1), was approximately 150 ac-ft per year (based on flow records from October 1, 1996 through September 30, 2004. The peak flow rate measured during the same period was approximately 135 cfs (Table 3).

To predict surface water discharge volumes for the site configuration after accelerated actions are complete, the MIKE SHE model was used, which simulates multiple integrated hydrologic processes, including surface water and groundwater interaction. A description of the MIKE SHE model, including model uncertainties, is provided in the Site-Wide Water Balance Modeling Report for RFETS (K-H 2002a). It is noted that the model results are best used to assess relative changes in hydrologic variables, versus their absolute values, as a result of changing conditions in the watershed or in climatic changes.

With accelerated actions complete, it is anticipated that flows in North Walnut Creek will be significantly diminished compared with the historic configuration of the site, when buildings and pavement generated additional runoff. The annual discharge volume predicted at station SW093 after accelerated actions are complete, based on model simulations for a typical climate year (Water Year 2000), is approximately 51 ac-ft per year. A range of model-predicted annual discharge volumes for station SW093, for varying climatic conditions, is presented in Table 5.

5.2.4 South Walnut Creek

Runoff from the central portion of the IA OU flows into South Walnut Creek, which has five retention ponds (Ponds B-1, B-2, B-3, B-4, and B-5). A summary description of the dams, flow routing, and pond operating protocol in South Walnut Creek is provided in Table 4. South Walnut Creek upstream from Pond B-5 is classified as stream segment 5 in the Big Dry Creek basin by the Colorado WQCC; downstream from Pond B-5, South Walnut Creek is classified as stream segment 4b (Figure 11).

Similar to North Walnut Creek, South Walnut Creek has continuous flow (as measured at gaging station GS10, located immediately downstream from the IA OU). The hydrology of the South Walnut Creek drainage following accelerated remedial actions is expected to differ from the hydrology when the IA existed. Removal of buildings, elimination of water historically imported for RFETS operations, elimination of the Sewage Treatment Plant discharge, and removal of pavement from the IA significantly reduce the volumes and peak discharge rates of runoff in this drainage (K-H 2002a).

When buildings and pavement existed in the IA, the mean annual discharge volume from South Walnut Creek, measured at gaging station GS10 (located above Pond B-1), was approximately 103 ac-ft per year (based on flow records from October 1, 1996 through September 30, 2004). The peak flow rate measured at GS10 during the same period was approximately 113 cfs (Table 3).

With accelerated actions complete, it is anticipated that flows in South Walnut Creek will be significantly diminished compared with the historic configuration of the site, when buildings and pavement generated additional runoff. The annual discharge volume predicted at station GS10 after accelerated actions are complete, based on model simulations for a typical climate year (Water Year 2000), is approximately 12 ac-ft per year. A range of model-predicted annual discharge volumes for station GS10, for varying climatic conditions, is presented in Table 5.

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5.2.5 Walnut Creek

Downstream from terminal Ponds A-4 and B-5, North and South Walnut Creeks merge to form Walnut Creek. This reach of Walnut Creek is classified as stream segment 4b in the Big Dry Creek basin by the Colorado WQCC (Figure 11).

When buildings and pavement existed in the IA, the mean annual discharge volume measured at gaging station GS03 (at Walnut Creek and Indiana Street) was approximately 453 ac-ft per year (based on flow records from October 1, 1996 through September 30, 2004). The peak flow rate measured during the same period was approximately 57 cfs (Table 3). As noted in the earlier discussions for North and South Walnut Creeks, flows in Walnut Creek following accelerated remedial actions are expected to be reduced substantially compared to flows when the IA existed.

With accelerated actions complete, it is anticipated that flows in Walnut Creek will be significantly diminished compared with the historic configuration of the site, when buildings and pavement generated additional runoff. The annual discharge volume predicted at station GS03 after accelerated actions are complete, based on model simulations for a typical climate year (Water Year 2000), is approximately 56 ac-ft per year. A range of model-predicted annual discharge volumes for station GS03, for varying climatic conditions, is presented in Table 5.

In addition to the Walnut Creek tributaries discussed in earlier sections, several other small drainage swales exist on the western side of Indiana Street, within the RFETS boundary. These drainages are tributary to Walnut Creek, but merge with Walnut Creek downstream from the site boundary (Figure 10). Therefore, the runoff from these small drainages is not measured by station GS03. These vegetated sub-basins were not altered by accelerated remedial actions. Although these catchments generate little runoff, they are noted here to complete the description of the Walnut Creek watershed.

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5.2.6 Walnut Creek Flow Off-Site

Downstream from the site, east of Indiana Street, Walnut Creek flows into a splitter box operated by the City of Broomfield. The splitter box is normally configured to divert Walnut Creek flows into the Broomfield Diversion Ditch and around the south side of Great Western Reservoir, thereby preventing RFETS runoff in Walnut Creek from entering the reservoir (Figure 1). East of the reservoir, the Broomfield Diversion Ditch angles northward and rejoins Walnut Creek.

Great Western Reservoir was formerly used to store the drinking water supply for the City of Broomfield. However, during the 1990s, the Great Western Reservoir Replacement Project was implemented as part of the "Option B" project, funded by DOE to protect downstream water supplies from potential RFETS contamination.[3] The Great Western Reservoir Replacement Project involved the purchase of water rights, construction of a pipeline from Carter Lake (located near Loveland, Colorado) to Broomfield, construction of a drinking water treatment plant, and development of associated infrastructure. Great Western Reservoir was then taken off-line as a drinking water supply reservoir, in accordance with terms of the grant that funded the project, although it is still used by the City of Broomfield as a storage facility for irrigation water.

East of Great Western Reservoir, Walnut Creek flows into Big Dry Creek. The 86-square-mile Big Dry Creek watershed is tributary to the South Platte River. The confluence of Big Dry Creek with the South Platte River is located north of Brighton, Colorado, approximately 30 miles northeast of RFETS.

[3] In the early 1990s, DOE, Westminster, Broomfield, and Congressman David Skaggs evaluated options for protecting downstream drinking water supplies from potential contamination from Rocky Flats. "Option B" was ultimately selected in 1991, and consisted of two major components: 1) the Great Western Reservoir Replacement Project (Section 5.2.6), and 2) the Standley Lake Protection Project (Section 5.3.6).

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5.3 Woman Creek

Woman Creek traverses the southern side of the site, and captures runoff from the southern portion of the IA OU as well as the majority of the southern BZ OU (Figure 10). The area of the on-site portion of the Woman Creek watershed is approximately 3.1 square miles. Several tributaries to Woman Creek exist within the RFETS boundaries, and include, from north to south: the South Interceptor Ditch (SID), North Woman Creek, Owl Branch, and Antelope Springs Gulch. While flows in the SID are anticipated to be reduced following completion of all accelerated actions, the hydrology in the Woman Creek tributaries is expected to remain unchanged between the historic and future configuration of RFETS. Descriptions of these tributaries, the main channel of Woman Creek, and the off-site flow of Woman Creek, are provided in Sections 5.3.1 through 5.3.6.

5.3.1 South Interceptor Ditch

Runoff from the southern portion of the IA OU flows into the SID. The SID was constructed to intercept runoff from the southern portion of the IA so that it would flow into Pond C-2 instead of directly into Woman Creek. A summary of Pond C-2 dam and pond characteristics, and the operating protocol, is provided in Table 4. As a tributary to the main stem of Woman Creek, the SID is classified as stream segment 4a in the Big Dry Creek basin by the Colorado WQCC.

The SID is a grass-lined, trapezoidal channel that flows intermittently. Removal of impervious surfaces, such as buildings and pavement, from the IA OU reduces the discharge volumes and peak flow rates observed historically. In addition, the western 1,500 feet of the SID were eliminated when the cover was constructed for the Original Landfill.

When buildings and pavement existed in the IA, the mean annual discharge volume in the SID, as measured at gaging station SW027 (located at the downstream, or eastern end, of the SID), was approximately 23 ac-ft per year (based on flow records from October 1, 1996 through September 30, 2004). The peak flow rate measured during the same period

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was approximately 10 cfs (Table 3). However, as noted above, flows in the final configuration are anticipated to be significantly less than runoff from the historic configuration, when buildings and pavement generated additional runoff.

With accelerated actions complete, it is anticipated that flows in the SID will be significantly diminished compared with the historic configuration of the site, when buildings and pavement generated additional runoff. The annual discharge volume predicted at station SW027 after accelerated actions are complete, based on model simulations for a typical climate year (Water Year 2000), is approximately 2 ac-ft per year. A range of model-predicted annual discharge volumes for station SW027, for varying climatic conditions, is presented in Table 5.

5.3.2 North Woman Creek

North Woman Creek flows from west of the site on to the southwest quadrant of the RFETS property, and converges with the Owl Branch of Woman Creek at a point approximately 1,800 feet east of the site's western boundary. North Woman Creek is hydrologically isolated from the IA OU. As a tributary to the main stem of Woman Creek, North Woman Creek is classified as stream segment 4a in the Big Dry Creek basin by the Colorado WQCC (Figure 11). Downstream from the confluence between North Woman Creek and Owl Branch, the channel is known as Woman Creek.

Changes made to the site from accelerated actions are not expected to alter the watershed or hydrology in North Woman Creek. The mean annual discharge volume measured at gaging station GS05 (located on the RFETS western boundary where North Woman Creek enters the site) was approximately 109 ac-ft per year (based on flow records from October 1, 1996 through September 30, 2004). The peak flow rate measured during the same period was approximately 25 cfs (Table 3).

5.3.3 Owl Branch

The Owl Branch of Woman Creek flows west on to the southwest quadrant of the RFETS property, and roughly parallels North Woman Creek before joining it at a point

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approximately 1,800 feet east of the site's western boundary. Owl Branch is hydrologically isolated from the IA OU. As a tributary to the main stem of Woman Creek, Owl Branch is classified as stream segment 4a in the Big Dry Creek basin by the Colorado WQCC (Figure 11).

Changes made to the site from accelerated actions are not expected to alter the watershed or hydrology in the Owl Branch of Woman Creek. The mean annual discharge volume measured in Owl Branch at gaging station GS06 (located on the RFETS western boundary where South Woman Creek enters the site), was approximately 21 ac-ft per year (based on flow records from October 1, 1996 through September 30, 2004). The peak flow rate measured during the same period was approximately 12 cfs (Table 3).

5.3.4 Antelope Springs Gulch

Antelope Springs Gulch conveys water from Antelope Springs, which normally flows throughout the year. Antelope Springs is located on the southern side of Woman Creek, in the southwest quadrant of the BZ OU. The seep is likely influenced by Rocky Flats Lake, located off-site to the west. Antelope Springs Gulch flows northeast and joins Woman Creek approximately 2,500 feet upstream from Pond C-1. The Antelope Springs drainage is hydrologically isolated from the IA OU. As a tributary to the main stem of Woman Creek, Antelope Springs Gulch is classified as stream segment 4a in the Big Dry Creek basin by the Colorado WQCC.

Changes made to the site from accelerated actions are not expected to alter the watershed or hydrology in Antelope Springs Gulch. The mean annual discharge volume of Antelope Springs Gulch, measured at gaging station GS16, was approximately 96 ac-ft per year (based on flow records from October 1, 1996 through September 30, 2004). The peak flow rate measured during the same period was approximately 9 cfs (Table 3).

5.3.5 Woman Creek

The stream channel downstream of the confluence between North Woman Creek and Owl Branch is known as Woman Creek. Between the North Woman Creek/Owl Branch

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confluence and Pond C-2, Woman Creek is isolated from the IA OU, in terms of surface runoff, because the SID intercepts surface flow and diverts it into Pond C-2. However, groundwater from portions of the southern IA OU discharges into Woman Creek. Woman Creek is designated as stream segment 4a in the Big Dry Creek basin by the Colorado WQCC, similar to North Woman Creek and Owl Branch.

In the western reach of Woman Creek, the watershed was enlarged when the Original Landfill remediation eliminated the western 1,500 feet of the SID, thereby allowing runoff from the Original Landfill area to flow directly to Woman Creek. However, because the vegetated cover on the Original Landfill will not generate a substantial quantity of runoff, this change is expected to have a negligible effect on the total flow volume in Woman Creek.

Woman Creek flows through Pond C-1, which was reconfigured as a low-profile, flow-through structure in 2005. A summary of the Pond C-1 dam and pond characteristics, and the operating protocol, is provided in Table 4. Below Pond C-1 and upstream from Pond C-2, Woman Creek is diverted, via a concrete diversion wall and channel, around the northern side of Pond C-2. The channel diversion was constructed so that Pond C-2 would capture only runoff from the IA and be isolated from the flow in Woman Creek. Downstream from Pond C-2, the diversion channel rejoins the original Woman Creek channel.

Pond C-2 is discharged into Woman Creek. Historically, when buildings and pavement existed in the IA, a Pond C-2 discharge was typically necessary once per year. However, with the reduced runoff from the IA OU flowing into the SID, Pond C-2 discharges to Woman Creek are expected to be less frequent, based on normal climate conditions. Because Pond C-2 discharges were historically a small percentage of the volume measured in Woman Creek, less frequent Pond C-2 discharges should not have a major impact on the overall hydrology of Woman Creek.

For the Woman Creek drainage, the mean annual discharge volume measured at gaging station GS01 (located on Woman Creek at Indiana Street) was approximately 269 ac-ft

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per year (based on flow records from October 1, 1996 through September 30, 2004). The peak flow rate measured during the same period was approximately 80 cfs (Table 3).

With the exception of the SID basin, changes made to the site resulting from accelerated remedial actions are not expected to have a major impact on the Woman Creek watershed or its hydrology. Based on model simulations of the site after accelerated actions have been completed, the annual discharge volume predicted at station GS01, for the Water Year 2000 climate, is approximately 130 ac-ft per year. For varying climatic conditions, a range of model-predicted annual discharge volumes for station GS01 is presented in Table 5.

5.3.6 Woman Creek Flow Off-Site

Woman Creek is part of the Big Dry Creek basin, similar to Walnut Creek. Downstream from the site, east of Indiana Street, Woman Creek flows into Woman Creek Reservoir. Woman Creek Reservoir was constructed in 1996 as a major component of the Option B water management project. The 400 ac-ft reservoir was constructed to capture Woman Creek surface water from RFETS before it flows into Standley Lake, which stores water for municipal drinking supplies and irrigation (CH2M-Hill 1996).

The Woman Creek Reservoir is operated by the Woman Creek Reservoir Authority. Water stored in the reservoir is detained until analytical results indicate the water quality is acceptable for discharge. Water is normally pumped north, via an underground pipeline, to Walnut Creek at a point east of Great Western Reservoir. Occasionally, water from Woman Creek Reservoir is pumped to Mower Reservoir and used for irrigation. Mower Reservoir is located immediately north of Woman Creek Reservoir.

5.4 Smart Ditches

Two irrigation ditches, Smart Ditch I and Smart Ditch II, exist in the southern portion of the RFETS BZ (Figure 10). Both are owned and operated by the Church Estate, not DOE or its contractors. Neither of the ditches receive runoff from the IA OU.

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Smart Ditch I fills two ponds (D-1 and D-2), located in the southeastern corner of the BZ OU, which are used for irrigation. Water from Rocky Flats Lake, located west of the site, flows through Smart Ditch I for approximately 2.5 miles before reaching a splitter box, which diverts water toward the southeast, into Ponds D-1 and D-2. Overland runoff is also intercepted and conveyed by Smart Ditch I.

Smart Ditch II runs northeast of Rocky Flats Lake and is used to flood-irrigate a pasture west of RFETS. Both Smart Ditch I and Smart Ditch II are typically dry, although each has an estimated flow capacity of 10 cfs. Because both ditches are hydrologically separated, as well as far removed, from the IA, limited flow or water quality data exist for these conveyances. Data for these ditches are not presented in this report.

6.0 HYDROGEOLOGY

This section describes the hydrogeology of the site, including the unconfined and confined groundwater systems present. Unconfined groundwater flow occurs in unconsolidated geologic materials and in subcropping weathered bedrock claystones and sandstones comprising the UHSU. In addition to the UHSU, a lower hydrostratigraphic unit (LHSU) has been identified at the site. The UHSU and LHSU are separated by extremely low-permeability claystone that serves to isolate them hydraulically. Background geochemical characterization of the UHSU and LHSU, based on major ion and stable isotope chemistry, shows that these units have statistically different groundwater chemistry, which provides further evidence of their hydraulic isolation from each other (EG&G 1993, 1995d). In addition, areas of the UHSU contain contaminant concentrations above drinking water standards, while the LHSU does not. Because the LHSU is hydraulically isolated from the UHSU, and because the LHSU does not show evidence of contamination from the UHSU, the LHSU is not a concern as a contaminant transport pathway from RFETS.

The term "aquifer", as defined by 40 Code of Federal Regulations (CFR) Section 260.10, is a "geologic formation, group of formations, or a part of a formation that is capable of yielding a significant amount of water to a well or spring." An uppermost aquifer is also defined as "the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility's boundary." The UHSU is considered equivalent to the uppermost aquifer at RFETS, although in many UHSU monitoring wells the amount of water available is insufficient to meet the definition of aquifer given above. While some UHSU monitoring wells are capable of producing enough groundwater for residential uses (K-H 2002b), groundwater at the site has never been used for drinking water, and this use is not anticipated in the future.

6.1 Regional Setting

The unconfined UHSU includes unconsolidated surficial materials, weathered portions of the Arapahoe and Laramie Formations, and all sandstones within the Arapahoe and Laramie Formations that are in hydraulic connection with overlying surficial deposits or the ground surface. Seeps are found along valley slopes at the contact of the surficial deposits and the underlying weathered bedrock. Water levels measured in UHSU versus bedrock wells at RFETS generally indicate a downward vertical hydraulic gradient. This suggests that water in the UHSU is perched on and bounded by claystone and silty claystone of the Arapahoe Formation (EG&G 1995b).

Beneath the surficial materials and consolidated deposits of the UHSU are the geologic units of the LHSU. The LHSU consists of the consolidated, unweathered bedrock of the Arapahoe and upper Laramie Formations that is not in hydraulic communication with the overlying UHSU. The Arapahoe and upper Laramie Formations comprising the geologic units of the LHSU consist of small quantities of sandstone and large quantities of claystones and siltstones. Because of the low permeability of the unweathered claystones, they restrict hydraulic communication with the UHSU (EG&G 1995b). LHSU wells that are screened in sandstones and bounded by relatively impermeable claystones and silty claystones exhibit confined conditions. In places where the uppermost LHSU sandstone is separated from UHSU materials by claystones and silty claystones, the sandstone may exist in a semi-confined condition (EG&G 1995b).

6.2 Hydraulic Conductivities

Hydraulic conductivities within the UHSU are important with regard to contaminant transport at the site. Hydraulic conductivity values commonly used for calculations have been obtained from the geometric mean values presented in Table G-2 of the Hydrogeologic Characterization Report (EG&G 1995b), with updated geometric mean values for the RFA and VFA, including data from approximately 40 additional aquifer tests performed in 1995.

Geometric mean hydraulic conductivities for the materials that comprise the UHSU are as follows:

- RFA — 4.18×10^{-4} centimeter per second (cm/sec);
- VFA — 9.20×10^{-4} cm/sec;
- Colluvium — 9.33×10^{-5} cm/sec;
- Arapahoe No. 1 Sandstone — 7.88×10^{-4} cm/sec; and
- Weathered Claystone — 8.82×10^{-7} cm/sec.

Although geochemical and hydraulic data show the UHSU and LHSU are isolated from each other, in theory limited hydraulic connection exists between these two units because of the downward vertical gradient between them. Hydraulic conductivities for the geologic materials separating the UHSU from the LHSU range from approximately 2.5×10^{-7} to 2.8×10^{-10} cm/sec (RMRS 1996). This extremely low conductivity, coupled with the depth to the LHSU, limits the vertical migration of contaminants from the UHSU to the LHSU to the extent that this is not a viable contaminant transport pathway (Hurr 1976; RMRS 1996).

6.3 Groundwater Occurrence and Distribution

RFETS is located in a regional groundwater recharge area (EG&G 1991). UHSU groundwater recharge in the IA OU occurs from the infiltration of incident precipitation with a minor contribution as base flow from the upgradient area of the drainage basin that extends west to Coal Creek. Generally, water levels are highest in spring and early summer and lowest during the winter months. Groundwater recharge in the BZ OU

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occurs from stream, ditch, and pond seepage. Groundwater recharge to confined aquifers of the LHSU and the lower Laramie Formation and Fox Hills Sandstone occurs as precipitation infiltrates the steeply dipping western edge of the Denver Basin, west of RFETS.

In the western part of RFETS, where the thickness of the RFA may exceed 100 feet, the depth to UHSU groundwater is 50 to 70 feet below ground. The depth to water generally becomes shallower, and the saturated thickness thinner, from west to east as the alluvial material thins and the underlying claystones are closer to the ground surface.

6.3.1 Groundwater Flow

At RFETS, unconfined groundwater flows vertically and horizontally within the UHSU materials and horizontally along the contact of the UHSU with the unweathered bedrock. The general flow direction is from west to east, with local variations toward drainages. UHSU groundwater flow is largely controlled by the topography of the bedrock surface. The potentiometric surface of groundwater in the UHSU has been mapped for the second and fourth quarters of 2003, and is shown on Figure 12 and Figure 13, respectively. The periods illustrated, spring and fall, represent the times of year when static water levels are expected to be highest and lowest, respectively.

Groundwater discharges from the UHSU to streams and seeps. Base flow in some of the perennial reaches is partially sustained by groundwater discharge. Seep discharge from the UHSU occurs at the head of stream drainages and along valley sides. Seeps are common on north-facing slopes where evapotranspiration (ET) is not as prominent, and occur at the base of the RFA or colluvium where they are in contact with claystones and sandstones of the Arapahoe/Laramie Formations. Seepage resulting from discharge of UHSU groundwater commonly appears as moist or wet areas on north-facing slopes even during relatively dry periods. Seep areas may be marked by the presence of phreatophytes (plant species with roots that extend to the water table). The seeps generally provide insufficient water to become sources of overland flow; flow rates have not been estimated. Seep locations denoted in the 1995 Hydrogeologic Characterization

Report (EG&G 1995b), based on prior mapping, aerial photography, and field reconnaissance, are displayed on Figure 14.

7.0 METEOROLOGY

RFETS has a semiarid climate typical of much of the central Rocky Mountain region, characterized by dry, cool winters and warm summers. The topography of the area greatly influences the climate, with higher elevation areas of the Front Range immediately to the west and gently rolling plains to the east.

7.1 Precipitation

Average annual precipitation at the site is approximately 14.3 inches (36.3 centimeters [cm]), based on 43 years of precipitation records.[4] Rainfall is highest from April through June, with approximately 41 percent of the average annual precipitation, as either rain or snow, occurring during those months. Fall and winter are typically drier seasons. Monthly precipitation data are summarized in Table 6.

Analysis of precipitation data collected at RFETS from 1993 through 2004 indicates that approximately 25 percent of the days had precipitation measured above 0.01 inch (0.025 cm). Only slightly more than 1 percent of the days had precipitation measured at a depth greater than 0.5 inch (1.3 cm).

Intense rainstorms along the Front Range are frequently of relatively short duration. Analysis of a 73-year record of rainfall at the Denver rain gage revealed that of the 73 most intense storms analyzed, 68 had the most intense period begin and end within the first hour of the storm. Furthermore, 52 of the storms had the most intense period begin and end within the first half-hour of the storm (UDFCD 2001). This pattern of highest intensity early in a rainstorm is common for storm events observed at RFETS.

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[4] Forty-three years of precipitation record includes data from 1964 through 1977 (AeroVironment 1995), 1984 through 1993 (AeroVironment 1995), and 1994 through 2004 (K-H precipitation data).

7.2 Temperature

Temperatures at RFETS are relatively moderate; extremely warm and cold weather is usually of short duration. Average daily temperatures in July range from 58° Fahrenheit (F) to 85°F (14° Celsius [C] to 29°C), while average daily temperatures in January range from 20°F to 47°F (-9°C to 8°C) (AeroVironment 1995). The growing season, from the last spring freeze to the first autumn freeze, is approximately 148 days per year (RMRS/DOE, 1995). Monthly temperature data, collected between 1964 and 2004, are summarized in Table 7.

7.3 Winds

Winds at RFETS, although variable, are predominately from the northwest quadrant. Wind speeds at 10 meters (m) above ground level average between 9 and 10 miles per hour (mph) (4 to 4.5 meters per second [m/s]). Strong winds occur predominantly out of the west-northwest, and during the winter and spring months. RFETS occasionally experiences gusts in excess of 100 mph (45 m/s). Strong winds are generally associated either with frontal passages or "Chinook" episodes, caused by the acceleration of westerly winds due to pressure differences over the Front Range, resulting in warm, dry, gusty conditions. Monthly wind speed data, collected between 1964 and 2004, are summarized in Table 8.

During periods when RFETS is not under the influence of strong storm systems or other synoptic patterns, the topographic differences between the western and eastern portions of the site produce a daily cycle of thermally driven upslope/downslope flow. Light winds flow upslope during the day as the warming land surface heats the adjacent air, with downslope winds occurring as the land surface cools after sunset. The distribution of wind speed and direction, based on 2004 data, is shown on Figure 15.

Stability reflects the tendency for vertical motion in the atmosphere and can be an important factor in determining air pollutant concentrations, as more stable conditions inhibit vertical dilution or pollutants emitted near ground level. Unstable conditions occur at RFETS approximately 11 percent of the time (RMRS/DOE 1995). Stable conditions occur approximately 43 percent of the time, while neutral conditions occur with the highest frequency, 46 percent of the time (RMRS/DOE 1995).

A temperature inversion, where warmer air overlies cooler air at the surface, often acts as a "lid" to hold pollution near the ground. Temperature inversions are common at RFETS and develop on most cloudless nights, even in the summer. During winter, such inversions can persist all day. Inversions can also occur when there are high winds aloft.

8.0 HUMAN POPULATIONS AND LAND USE

As discussed in Section 0, RFETS is located at the interface of the Great Plains and Rocky Mountains. Higher elevation areas west of RFETS are characterized by rugged terrain and relatively sparse human population. In contrast, the plains east of RFETS are characterized by relatively gentle topography and higher population density associated with the greater Denver metropolitan area. RFETS is located in an area of growing population with residential and commercial development of lands historically used for farming and grazing, primarily to the north, east, and south. This development is somewhat countered by local government acquisition and preservation of open space, including land adjacent to RFETS, primarily directly to the west and north.

8.1 Population and Housing

As of 2004, approximately 2.6 million people were living in the Denver metropolitan area counties. Between 1990 and 2000, the population of the Denver metropolitan area increased by approximately 556,000 people (29.9 percent), according to the Denver Regional Council of Governments (DRCOG) (DRCOG 2004).

Table 9 presents the population and number of households in Denver-area counties in 2000, along with the estimated population and household numbers for 2004. The distribution of households and population within a radius of 20 kilometers (12.4 miles) of the site in 2004 is shown on Figure 16. Continued growth is expected for these areas. DRCOG projects the population in the Denver metropolitan area will increase by more than 1 million additional people from 2000 to 2025, or approximately 42 percent (DRCOG 2004).

In addition to the trend of increasing population in adjacent counties, residential population has moved closer to the site since 1990. The communities of Superior (north of RFETS), Broomfield (northeast of RFETS), and Westminster and Arvada (east and southeast of RFETS) have experienced rapid growth in recent years. As a result, residential housing, as well as increased commercial and industrial uses, have developed primarily to the north, northeast, east, and southeast of RFETS, in areas that were vacant land when the 1990 census was conducted. Some of these developments are described in more detail in Section 8.2.

8.2 Surrounding Land Use

Until recently, land around the site consisted primarily of rangeland, preserved open space, mining areas, and low-density residential areas. However, this rural pattern is beginning to change due to the spread of development from the surrounding communities. The towns of Superior and Broomfield have already experienced extensive development north and northeast of the site. Superior has seen substantial residential growth, and a commercial center has been developed at the intersection of McCaslin Boulevard and U.S. Highway 36 (Figure 1).

Northeast of the site, an extensive area of commercial, residential, and office space (Interlocken and the Flatirons Crossing area) has developed over the past five to seven years between State Highway 128 and U.S. Highway 36. During this same period, several office complexes, a county jail, and multifamily residential housing has been constructed south of State Highway 128 and east of Indiana Street. In addition, the Jefferson County Airport, located approximately 3 miles east of RFETS, is surrounded by recent business park and light industrial developments.

State-owned lands southwest and west of the site are used for grazing, mining, and storage and conveyance of municipal water supplies. Along Highway 93, an area of land approximately 1,200 feet wide adjacent to the site's western boundary is available for eventual development, open space, or highway right-of-way. The 259-acre DOE National Wind Technology Center is located adjacent to the northwestern corner of the BZ OU on lands transferred from the DOE Rocky Flats Project Office (RFPO). Preserved open space is the primary existing and proposed use of the lands immediately north (Boulder County and City of Boulder) and east (Cities of Broomfield and Westminster) of the site.

Areas within the BZ OU and adjacent privately-owned lands west of the site have been permitted by the State and County for mineral extraction (primarily clay, sand, and gravel mining). Some irrigated and nonirrigated croplands, producing primarily wheat and barley, are located northeast of RFETS near the Cities of Broomfield, Lafayette, and Louisville; north of RFETS near Louisville and Boulder; and in scattered parcels adjacent to the eastern boundary of the site. Much of the rest of the land immediately adjacent to RFETS is used for cattle grazing.

To the south, several horse operations and small hay fields exist at present. However, a mixed-use residential and commercial development known as Vauxmont, within the City of Arvada, is proposed for an area immediately adjacent to the southern boundary of the site (FWS 2004a). By 2020, DRCOG projects that the entire area south of the site will be developed, as well as areas to the southeast that are either not already developed or protected as open space (City of Westminster) around Standley Lake.

8.3 Natural Heritage Resources

The Refuge Act identifies the following significant RFETS qualities:[5]

- The majority of the site has generally remained undisturbed since its acquisition by the government;

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[5] Chapter 3 of the Rocky Flats National Wildlife Refuge Final Comprehensive Conservation Plan and Environmental Impact Statement also contains detailed descriptions of the habitat communities (FWS, 2004a).

- The site preserves valuable open space and striking vistas of the Front Range mountain backdrop; and
- The site provides habitat for many wildlife species, including a number of threatened and endangered species, and is marked by the presence of rare xeric tallgrass prairie plant communities.

The Colorado Natural Heritage Program (CNHP),[6] a research entity of the Nature Conservancy housed at Colorado State University's College of Natural Resources, assessed the BZ OU for its ecological value (CNHP 1994; 1995). CNHP concluded the site contains highly significant natural elements important for the protection of Colorado's natural diversity and encouraged DOE to take actions to protect and appropriately manage the site.

CNHP classifies the xeric tallgrass prairie plant community as very rare. The RFETS macrosite was identified by CNHP as the largest known remnant of xeric tallgrass prairie in Colorado, and probably the largest remaining parcel in all of North America (CNHP 1994, 1995). Most of the remaining xeric tallgrass prairie in Colorado is found in Boulder and Jefferson Counties in small, dispersed parcels. Less than 20 occurrences of the xeric tallgrass prairie are known worldwide. Approximately 1,800 acres of this xeric tallgrass prairie unit occurs within site boundaries.

The Great Plains riparian community, identified by CNHP as Great Plains riparian woodlands and riparian shrublands, is classified as rare and declining. Examples of this community are found in the Rock Creek, Walnut Creek, Woman Creek, and Smart Ditch drainages (CNHP 1994; CNHP 1995). Approximately 54 acres of this type (includes

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[6] The CNHP is an independent, multidisciplinary group of ecologists that gather information on rare species and habitats and maintain the Biological and Conservation Databases (designed by the Nature Conservancy). Using databases that provide site-specific information for given species and habitats, they are able to rank and prioritize areas representing the nation's natural biodiversity. Priorities can then be established for the protection of the most sensitive areas to help in determining land use options.

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riparian woodland, willow riparian shrubland, and lead plant riparian shrubland) occurs within the site boundary.

The tall upland shrubland community is found on north-facing slopes primarily in the Rock Creek drainage and was identified by CNHP as a potentially unique shrubland community, possibly not occurring anywhere else. This community commonly occurs just above wetlands and seeps (CNHP 1994). Although the tall upland shrubland represents less than 1 percent of the total area of Rocky Flats, it contains 55 percent of the plant species on the site.

8.4 Cultural Resources

Two archeological surveys were conducted at RFETS, in 1989 and 1991. These surveys identified local points of interest in the BZ OU, such as Lindsay Ranch and an apple orchard. However, at that time, no sites or artifacts were found to be eligible for listing on the National Register of Historic Places (DOE 2000).

A survey of the IA OU was prepared in 1995 (AeroVironment 1995). The survey report concluded several facilities in the IA are of historic importance because of the role they played in the site's contribution to the Cold War. The State Historic Preservation Office (SHPO) agreed with these conclusions. Subsequent discussions with the SHPO determined how the historic information at the site would be recorded.

On January 16, 1998, 64 buildings and facilities at RFETS were included in a district that was formally added to the National Register of Historic Places. An Historic American Engineering Record (HAER) for the RFETS district was created using various reports, photographs, and drawings to document the history and significant contributions from 1953 to 1992 for the Rocky Flats Plant (DOE 1998). The HAER program was established in accordance with the 1935 Historic Sites Act (P.L. 74-292) and the 1966 National Historic Preservation Act (NHPA) (P.L. 89-665), as amended in 1980 (P.L. 96-515). The HAER program sets out to capture vanishing industrial and engineering treasures nationwide, in written historical reports. The RFETS district HAER was reviewed and accepted by the U.S. Department of Interior, National Park Service on

January 22, 1999, and the HAER was transmitted to the Library of Congress. As a result of the National Park Service accepting the HAER, decontamination, decommissioning, and demolition of buildings within the historic district complied with the NHPA requirements.

A Cultural Resource Management Plan (CRMP) (SAIC 1996) was prepared that incorporated information from both the archeological and IA OU surveys and established guidelines regarding how to manage site cultural resources.

8.5 Property Rights

8.5.1 Subsurface Rights

The majority of RFETS is subject to subsurface property rights held by private owners. Extraction of subsurface minerals has occurred on or adjacent to the western area of the site for at least the last 60 years, and historically has included mining of coal, clay, and sand and gravel. Active permits currently exist for surface mining of sand and gravel and clay in the northwest area of the former BZ. Lafarge West, Inc. holds a permit to mine sand, gravel, and clay in Section 4, called the Bluestone Pit. Church Ranch holds a permit to mine sand, gravel, and clay in the NE ¼ of the SE ¼ of Section 9, the Rocky Flats Pit. Lakewood Brick & Tile Company holds a permit to mine clay in the NW ¼ of the SE ¼ of Section 9, called the Church Pit. No other mining permits are currently in place within the site boundaries. Ownership of mineral rights for the site is presented on Figure 17.

8.5.2 Rock Creek Reserve

Rock Creek Reserve was created in May 1999 through a designation by the U.S. Secretary of Energy and execution of a cooperative agreement between DOE and the FWS for management of Rock Creek Reserve's ecologically important resources. Approximately 850 acres of the northern BZ was designated as Rock Creek Reserve for purposes of protecting and preserving the important wildlife, cultural, and open space resources in this area. DOE retains jurisdiction of the area and is responsible for access controls. Under the cooperative agreement, FWS manages the ecological resources. Most of the Rock Creek Reserve was part of several livestock ranches (most notably, the Lindsay Ranch) before DOE purchased the property.

In May 2001, DOE and FWS published the Integrated Natural Resources Management Plan and Environmental Assessment (DOE/FWS, 2001). This plan outlines steps proposed for the next five years to provide for the stewardship of the natural resources of the Rock Creek Reserve (also known as the Rock Creek Fish and Wildlife Cooperative Management Area). In this plan, the Rock Creek Reserve was expanded to 1,793 acres to include the entire northern boundary of the BZ (Figure 2).

Within the Rock Creek Reserve are areas that have been permitted for mining. Thus, certain mineral rights, as discussed in Section 8.5.1, are being exercised. As noted above, a mining permit, called the Bluestone permit, was granted by the Colorado Division of Mining and Geology, and a zoning variance was passed by the Jefferson County Commissioners in 1995. The permit and variance included part of the area that became designated the Rock Creek Reserve. The portion of the Bluestone permit area lying within Rock Creek Reserve is located in the northwest, and includes approximately 250 acres, of which approximately 20 acres are permitted for mining. The remaining 230 acres of the permitted area are designated as a nonmining buffer area. Mining operations have not yet begun in this area.

8.5.3 Easements

The RFETS property is subject to easements and licenses granted by the U.S. government to third parties, primarily public utilities. A list of the existing easements and licenses is provided in Table 10, and the locations of these easements and licensed areas are illustrated on Figure 3 (the reference numbers in Table 10 correspond to the numbers on Figure 3). The easements and licenses generally contain provisions for rights of access for the purposes of maintenance and operation.

8.6 Future RFETS Land Use

The Refuge Act designated Rocky Flats as Colorado's seventh National Wildlife Refuge. The designation will be effective upon achieving closure as defined in the Refuge Act, at which time jurisdiction of the areas of RFETS that become a wildlife Refuge will be transferred to the U.S. Department of the Interior for Refuge purposes.

The purposes of the Refuge, as listed in the proposed legislation, are as follows:

- Restoring and preserving native ecosystems;
- Providing habitat for and population management of native plants and migratory and resident wildlife;
- Conserving threatened and endangered species;
- Providing opportunities for compatible, wildlife-dependant environmental scientific research; and
- Providing the public with opportunities for compatible outdoor recreational and educational activities.

The following land management actions or implications are expected:[7]

- The U.S. Department of the Interior, specifically the FWS, will administer the Refuge.
- Land ownership will remain with the United States; however, jurisdiction for certain portions of RFETS will be transferred from DOE to the U.S. Department of the Interior.

[7] See the Refuge Act for its specific requirements. This Summary Report discussion is intended only as a brief overview of the Refuge Act requirements in relation to the anticipated future use of RFETS as a Refuge.

- The lands retained by DOE are expected to be managed consistent with the Refuge.

- Some portions of RFETS will be designated as exempt from transfer if they are to be used for water treatment; treatment, storage, or disposal of hazardous substances, pollutants, or contaminants; or other purposes related to response actions at RFETS and any actions required under any other statute to remediate contaminants.

- DOE will retain responsibilities to carry out long-term stewardship for remedial actions (such as maintenance and/or operation of landfill covers, groundwater remediation systems, surface water controls, surface water and groundwater monitoring, and other final land configuration features required to protect human health and the environment).

- It is likely that all management actions will continue to remain subject to provisions of the Endangered Species Act (ESA), the Migratory Bird Treaty Act, the Bald Eagle Protection Act, and the Fish and Wildlife Coordination Act.

- The Refuge fish and wildlife resources will be managed in a manner consistent with the goals and objectives established in the Final Rocky Flats National Wildlife Refuge Comprehensive Conservation Plan (CCP) and Environmental Impact Statement (FWS 2004a). These plans were developed based on consultation with State and local agencies as well as public input.[8]

- FWS will manage the Refuge to achieve the mission set forth in legislation establishing the Refuge in accordance with the National Wildlife Refuge System Administration Act.

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[8] A Final Rocky Flats National Wildlife Refuge CCP and Environmental Impact Statement was published by FWS after public review and comment (FWS, 2004a). This Site Physical Characteristics Summary Report will not be revised to update the progress toward Refuge establishment. Rather, the periodic reports on progress will be made publicly available by, or on behalf of, DOE and are hereby incorporated by reference. Also, the website www.rockyflats.fws.gov provides routinely updated information on the Refuge.

- Once designated as a National Wildlife Refuge, the transferred property will not be subject to annexation by any unit of general local government.

- The Refuge Act prohibits the United States from transferring any rights, title, or interest in land within the boundaries of Rocky Flats, except for the purpose of transportation improvements on the eastern edge of RFETS that is bordered by Indiana Street.

- It is anticipated that use of the land for residential, commercial or industrial purposes will not occur, and that surface water and groundwater will not be used for potable water supplies. The land is not anticipated to be used as cropland, although the CCP allows for limited livestock grazing for the purpose of vegetation management.

9.0 ECOLOGY

At an elevation of approximately 6,000 feet above MSL, the site contains a unique ecotonal mixture of mountain and prairie plant species resulting from the topography of the area and its proximity to the mountain front. The relatively undeveloped site provides numerous plant communities that are used by wildlife to satisfy habitat needs. Many of these plant communities are increasingly rare along the Front Range as urbanization continues to replace and fragment the remaining parcels of these plant communities. This section, which is largely a direct excerpt from the *Affected Environment* text in the CCP, provides a description of the vegetation, wildlife, and threatened and endangered species present at RFETS (FWS 2004a).[9]

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[9] The majority of text in this Ecology section is taken directly from the CCP (FWS 2004a). However, the text was modified in several cases to be consistent with findings from vegetation surveys documented in the 2001 Annual Vegetation Report for RFETS (K-H 2002c) and wildlife surveys documented in the 2000 Annual Wildlife Survey for RFETS (K-H 2001). In addition, latin names were added for plant and animal species referenced.

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9.1 Vegetation

A diverse range of vegetation communities is found at RFETS (Table 11). Two of these vegetation communities, the xeric tallgrass grassland and the tall upland shrubland, are considered rare in the region. Other significant vegetation communities at RFETS include the riparian woodland, riparian shrubland, wetlands, mesic mixed grassland, xeric needle and thread grassland, reclaimed mixed grassland, and ponderosa pine woodland (Figure 18). Vegetation communities at Rocky Flats have been grouped into Resource Management Zones. These zones generalize the Refuge into three categories with similar wildlife habitat attributes and management requirements. The three management zones are xeric tallgrass grassland, wetlands and riparian corridors, and mixed prairie grassland.

9.1.1 Xeric Tallgrass Grassland Management Zone

9.1.1.1 Xeric Tallgrass Grassland

This rare plant community is found on the rocky plains in the western portions of the site, extending eastward along several fingerlike ridgelines (Figure 18). The xeric tallgrass grassland covers 1,568 acres and contains several different plant associations that include combinations of big bluestem *(Andropogon gerardii)*, little bluestem *(Andropogon scoparius)*, mountain muhly *(Muhlenbergia montana)*, sun sedge *(Carex heliophila)*, Fendler's sandwort *(Arenaria fendleri)*, and Porter's aster *(Aster porteri)*. Other tallgrass prairie species include Indian-grass *(Sorghastrum nutans)*, prairie dropseed *(Sporobolus heterolepis)*, switchgrass *(Panicum virgatum)*, and needle-and-thread grass *(Stipa comata)*. Species richness is high; 295 species have been recorded within the xeric tallgrass community at the site, of which approximately 80 percent are native (K-H 2002c).

The xeric tallgrass grassland is believed to be a relict once connected to the tallgrass prairie hundreds of miles to the east (Nelson 2003; Essington et al. 1996). CNHP has found that much of the xeric tallgrass grasslands along the Colorado Front Range has been disturbed by urban development and agricultural conversion over the last century.

In addition, aggressive weed species, such as cheatgrass *(Bromus* ssp.*)*, Japanese brome *(Bromus japonicus)*, and diffuse knapweed *(Centaurea diffusa)*, have degraded many areas of this community throughout the region (Essington et al. 1996), as well as at RFETS. CNHP believes that the xeric tallgrass grassland community exists in fewer than 20 places globally and that RFETS has the largest example of this community remaining in Colorado and perhaps North America. CNHP ranks this community as imperiled within the state (Essington et al. 1996).

The xeric tallgrass grassland community is composed of several subcommunities (Nelson 2003). One of these subcommunities ~~was~~ identified by ESCO Associates Inc. (ESCO) during a five-year evaluation of bluestem-dominated grasslands in the RFETS area. This study found that the major distinguishing feature of what ESCO calls the rare "Rocky Flats Bluestem Grassland" community is the abundance of big bluestem with little bluestem, mountain muhly, and Porter's aster (Figure 18). While big and little bluestem are characteristic of Midwestern tallgrass prairies, mountain muhly and Porter's aster are characteristic of mountain environments. This unusual combination of mountain and plains grassland species in a consistent and recurring pattern across the Rocky Flats alluvial surface, along with evidence of exceptional stability, makes this vegetation community a rare, if not unique, resource (ESCO 2002).

In 2001, high winds deposited several inches of sand on xeric tallgrass grassland areas adjacent to existing gravel mines in the northwestern corner of the site (Figure 19). This sand buried most of the native vegetation and was soon colonized by sunflower *(Helianthus pumilus)*, a native annual weedy species, as well as noxious weeds such as diffuse knapweed, Russian thistle *(Salsola iberica)*, and kochia *(Kochia scoparia)*.

9.1.2 Wetlands and Riparian Corridors Management Zone

9.1.2.1 Riparian Woodland

The riparian woodland community is characterized by a diverse mixture of plains cottonwood *(Populus deltoides)*, peachleaf willow *(Salix amygdaloides)*, and Siberian elm *(Ulmus pumila)*, with an understory of various shrubs such as coyote willow *(Salix* *exigua),* false indigo (*Amorpha fruticosa*), and snowberry *(Symphoricarpos occidentalis).* Covering 28 acres, it is found primarily along the RFETS drainage bottoms, with the most significant stand occurring in the Rock Creek drainage (Figure 18) (K-H 1997; PTI 1997; Essington et al. 1996).

The most significant threat to the riparian woodland community is from exotic species such as Siberian elm, Canada thistle *(Cirsium arvense),* musk thistle *(Carduus nutans),* smooth brome *(Bromus inermis)*, and Kentucky bluegrass *(Poa pratensis).* Preservation of this woodland community depends on the preservation of associated streamflow (PTI 1997; Essington et al. 1996).

9.1.2.2 Riparian Shrubland

Riparian shrubland forms extensive, dense thickets of shrubs along the stream bottoms. This community covers 41 acres throughout RFETS (Figure 18). It is dominated by coyote willow and false indigo and generally has an understory consisting of Canada thistle (a noxious weed), meadow fescue *(Festuca pratensis),* Canada bluegrass *(Poa compressa),* Baltic rush *(Juncus balticus),* and various sedges (Kettler et al. 1994; USACE 1994; K-H, 1997).

9.1.2.3 Tall Upland Shrubland

Tall upland shrubland occurs on 34 acres of north-facing slopes above seeps and along streams, primarily within the Rock Creek drainage (Figure 18). The tall upland shrubland consists of a rare association of hawthorn *(Crataequs erythropoda),* chokecherry *(Prunus virginiana)*, and occasionally wild plum *(Prunus americana).* This shrubland is associated with groundwater seeps that form at the contact of the RFA and the underlying, relatively impermeable Arapahoe Formation. The herbaceous understory contains a number of species that are restricted to the cool, shaded microhabitat provided by the canopy. Understory species include Fendler waterleaf *(Hydrophyllum fendleri)*, spreading sweetroot *(Osmorhiza chilensis),* anise root *(Osmorhiza longistylis),* carrionflower greenbriar *(Smilax herbacea),* fragile fern *(Cystopteris fragilis),* Colorado violet *(Viola scopulorum)*, Rydberg's violet *(Viola rydbergii),* and northern bedstraw

(Galium septentrionale). Although the tall upland shrubland represents less than 1 pecent of the total area of RFETS, it contains 55 percent of the plant species on the site (DOE/FWS 2001). This shrubland community is believed to be rare and may not occur anywhere else (DOE/FWS 2001; Essington et al. 1996).

9.1.2.4 Other Shrubland

Other shrubland communities include short upland shrubland and savannah shrubland, covering 70 acres primarily in the Rock Creek drainage (Figure 18). Short upland shrubland is characterized by stands of snowberry and occasional Wood's rose *(Rosa woodsii)* and is often found in association with wet meadows and other wetland or riparian communities. Savanna shrubland occurs in drier areas where scattered shrubs are interspersed with grasslands. Three-leaf sumac *(Ruhus trilobata)* is the predominant shrub in this community (K-H 1997).

9.1.2.5 Wetland Communities

Wetland communities cover 406 acres of the site and play an important role in sustaining the diverse vegetation and habitat types found on the site. The most significant wetland complexes at RFETS are the seep-fed wetlands along the hillsides of the Rock Creek drainage and the Antelope Springs complex in the Woman Creek drainage (Figure 20). These wetlands are significant because they have the largest contiguous areas and the most complex plant associations (PTI 1997).

Three wetland types, tall marsh, short marsh and wet meadow, are found at the site. These occur in streamside areas along the valley floors and near the seeps and springs that occur along many of the hillsides. An inventory of wetlands, by watershed at RFETS, is summarized in Table 12. Each wetland type is described below.

9.1.2.6 Tall Marsh Wetland

Tall marsh wetlands generally occur along ponds and ditches and in persistently saturated seeps (Figure 18). Covering 31 acres of the site, these wetlands are dominated by cattails (*Typha* ssp.), bulrushes (*Scirpus* ssp), and associated forbs such as watercress

(Nasturtium officinale), showy milkweed *(Ascelepias speciosa),* swamp milkweed *(Ascelepias incarnata),* and Canada thistle. Antelope Springs in the Woman Creek drainage is the best example of a saturated slope wetland and tall marsh community at RFETS (Figure 20).

9.1.2.7 Short Marsh Wetland

The short marsh wetlands cover 121 acres at RFETS, and are commonly associated with seasonally inundated or saturated areas, such as hillside seeps (Figure 18). Prevalent species include Nebraska sedge (*Carex nebrascensis*), Baltic rush, and spike rush (*Eleocharis ssp.*), as well as forbs such as watercress and speedwell (*Veronica ssp.*)

9.1.2.8 Wet Meadow Wetland

These seasonally saturated wetlands occupy 254 acres on the perimeter of saturated wetlands and contain elements of both the short marsh wetland and upland mixed grassland communities (Figure 18). Prevalent species include redtop *(Agrostis stolonifera),* prairie cordgrass *(Spartina pectinata),* and solid stands of Canada bluegrass and western wheatgrass *(Agropyron smithii).* Other species commonly found in this community include common milkweed *(Asclepias speciosa),* wild iris *(Iris missouriensis),* Canada thistle, dock (*Rumex* ssp.), and occasionally arnica *(Arnica fulgens)* (Nelson 2003).

9.1.3 Mixed Prairie Grasslands Management Zone

9.1.3.1 Mesic Mixed Grassland

The mesic mixed grassland community is the largest vegetation community at RFETS, covering 2,199 acres across the broad ridges, hillsides, and valley floors throughout the site and the rolling plains in the eastern portions of the site (Figure 18). This community is characterized by western wheatgrass , blue grama *(Bouteloua gracilis),* side-oats grama *(Bouteloua curtipendula),* prairie junegrass *(Koeleria pyramidata),* Canada bluegrass, Kentucky bluegrass, green needlegrass *(Stipa virigula),* and little bluestem. This grassland occurs on clay loam soils having relatively higher soil moisture content

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than other upland areas. The higher moisture results from subirrigation from the coarse alluvial soils, snow accumulation, and protection from wind (DOE 1997).

The mesic mixed grassland is very important to wildlife species including grassland birds, small mammals, and larger mammals such as mule deer. The quality of mesic mixed grassland varies considerably across the site. In the western parts of the site, this community has been degraded by diffuse knapweed, while some areas in the eastern portion of the site have been degraded by weed species such as Japanese brome, alyssum *(Alyssum minus)*, and musk thistle *(Carduus nutans)* (PTI 1997).

9.1.3.2 Xeric Needle and Thread Grassland

Several patches of xeric grassland dominated by needle-and-thread grass occur in the eastern half of RFETS. These patches cover 187 acres (Figure 18). Other dominant grass species include New Mexico feathergrass *(Stipa neomexicana)*, Canada bluegrass, Kentucky bluegrass, and Japanese brome (Nelson 2003). This grassland occurs primarily on the eastern extensions of the Rocky Flats pediment that is characterized by very cobbly, sandy loam soils. Although not as cobbly, these soils are very similar to the soils that support the xeric tallgrass grassland community (K-H 1997). The largest expanse of needle-and-thread grassland at RFETS occurs along the ridgetop north of the former East Access Road.

9.1.3.3 Reclaimed Mixed Grassland

Reclaimed mixed grassland covers 640 acres, primarily in the southeastern portion of the site that was formerly cultivated for agriculture (Figure 18). Most of these areas have been reseeded with a mixture of smooth brome and intermediate wheatgrass *(Agropyron intermedium)*, both introduced species. Other common species include crested wheatgrass *(Agropyron cristatum)*, sweetclover (*Melitotus ssp.*), and field bindweed *(Convolvulus arvensis)* (K-H 1997).

9.1.3.4 Short Grassland

This grassland is typified by buffalograss *(Buchloe dactyloides)* and blue grama, both short grass prairie species. Ten acres of this community are found on the site (K-H 1997), typically in relatively small, isolated areas near the RFETS eastern boundary at Indiana Street.

9.1.3.5 Ponderosa Pine Woodland

Isolated patches of ponderosa pine woodland cover 9 acres in the uppermost reaches of the Rock Creek and Woman Creek drainages near the western edge of the site. These scattered pines represent an eastward extension of the nearby foothills forests. While much of the understory is similar to the adjacent grassland communities, other associated plants are more likely to occur in foothills environments (DOE 1997).

9.1.3.6 Disturbed and Developed Areas

Disturbed and developed areas consist of existing or former facilities associated with the previous use of the site. They include roads, landfills, dams, and other facilities, such as groundwater treatment systems. They also include former facilities that have been revegetated with native and introduced grass species.

9.1.4 Noxious Weeds

Noxious weeds are exotic, aggressive plants that invade native habitat and cause adverse economic or environmental impacts. Since 1990, the site has experienced a large increase in noxious weeds (DOE 1997). At RFETS, the noxious weed species with the greatest potential to degrade the native plant communities and that are the most difficult to control include diffuse knapweed, musk thistle, Dalmatian toadflax *(Linaria dalmatica),* and Canada thistle. Other increasingly problematic weeds are downy brome (cheatgrass) *(Bromus tectorum),* field bindweed, and jointed goatgrass *(Aegilops cylindrica)* (Lane 2004). Diffuse knapweed, an aggressive tumbleweed, is currently given highest control priority. Canada thistle is common in and around most of

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the wetlands, musk thistle is found across mesic grasslands, and Dalmatian toadflax is common in xeric grasslands and other areas (Figure 18).

Prioritized noxious weed lists and select weed control measures are found in the 2002 Annual Vegetation Management Plan (K-H 2002d). The three most abundant noxious weeds identified during 2001 mapping were diffuse knapweed (1,957 acres) (Figure 21), common mullein *(Verbascum thapsus)* (1,357 acres) (Figure 22), and musk thistle (869 acres) (Figure 23) (Table 13) (K-H, 2002d; DOE/FWS, 2001).

9.1.5 Rare Plants

No federally listed plant species, such as the Ute ladies'-tresses orchid *(Spiranthes diluvialis)* or Colorado butterfly plant *(Gaura neomexicana ssp. coloradensis),* are known to occur at RFETS. Aside from the rare xeric tallgrass prairie and tall upland shrubland communities, RFETS also supports populations of four plant species that are listed as rare or imperiled by CNHP. These species are the mountain-loving sedge *(Carex oreocharis),* forktip three-awn *(Aristida basiramea),* carrionflower greenbriar, and dwarf wild indigo *(Amorpha nana).* Forktip three-awn primarily occurs in previously disturbed sites near the western edge of the IA OU. The other three species occur primarily along the pediment slopes in the Rock Creek drainage (K-H 2002c).

9.1.6 Fire History

Historical documentation indicates grasslands in the RFETS area have been subjected to lightning- and human-caused fires for thousands of years (DOE 1999). These fires likely played a major role in promoting native vegetation growth and diversity (DOE 1999). Since 1972, wildfires have not been allowed to burn and only one controlled burn has been conducted in the grasslands at RFETS. As a result, a fuel load of dead vegetation has been building up in the grasslands at the site for at least 30 years. This buildup of dead vegetation has contributed to an invasion of noxious weeds on the site, particularly in the last 10 years (DOE 1999). Seven wildfires have been documented on the site since 1993. In addition, a prescribed burn was conducted on April 6, 2000. These grassland fires are summarized in Table 14.

9.2 Wildlife Resources

Many areas of the site have remained relatively undisturbed for the past 30 to 50 years, allowing them to retain diverse habitat and associated wildlife. These wildlife communities are supported by the regional network of protected open space that surrounds the site on three sides, buffering wildlife habitat from the surrounding urban development.

9.2.1 Mammals

One of the most abundant and conspicuous mammal species at RFETS is the mule deer *(Odocoileus hemiomus)*. A resident herd of approximately 160 individuals inhabits the site. While mule deer distribution varies by season, they appear to have a general preference for the following areas:

- Open grasslands of the upper Rock Creek drainage;
- Shrublands of the lower Rock Creek drainage;
- Grasslands of the upper Walnut Creek drainage;
- Hillsides above lower Walnut Creek;
- Riparian bottomlands around Woman Creek and Antelope Springs; and
- Grasslands below the pediment in the Smart Ditch drainage.

In the spring, mule deer exhibit an affinity for woody habitat and secondarily for grasslands. In the summer, deer use is more generally divided among different habitats. In the fall, mule deer primarily use woody habitats, with grasslands also being important. In the winter, mule deer are commonly observed in grasslands and tall upland shrublands (K-H 2001).

Whitetail deer *(Odocoileus virginianus)* have become more common at the site and are often observed in company with mule deer. RFETS is in Colorado Division of Wildlife (CDOW) Game Management Unit (GMU) #38 and is adjacent to GMU #29, which collectively make up the Boulder deer herd. American elk *(Cervus elahus)* visit the site, but are not resident (DOE 1997). In 2003, 11 cow elk were observed with 9 calves in the Rock Creek drainage (Wedermyer, 2003).

Other mammals observed at RFETS include the desert cottontail *(Sylvilagus audubonii),* white-tailed jackrabbit *(Lepus townsendii),* black-tailed jackrabbit *(Lepus californicus),* muskrat *(Ondatra zibethicus),* and porcupine *(Erethizon dorsatum).* Muskrats generally occur in and around the ponds, while porcupine populations are limited to the shrubland and ponderosa pine habitats in the upper Rock Creek drainage (DOE 1997). Black-tailed prairie dogs *(Cynomys ludovicianus)* inhabit the site in limited numbers and are discussed in greater detail below. Numerous small mammal species, such as the harvest mouse *(Reithrodontomys megalotis)*, deer mouse *(Peromyscus maniculatus),* pocket mouse *(Perognathus flavus),* meadow vole *(Microtus pennsylvanicus),* prairie vole *(Microtus ochrogaster),* and Mexican woodrat *(Neotoma mexicana),* inhabit all vegetation community types at Rocky Flats. The Preble's meadow jumping mouse (PMJM) *(Zapus hudsonius preblei),* a threatened species, is described in Section 9.3.1.

Two commonly observed carnivore species at RFETS are the coyote *(Canis latrans),* which occurs throughout the site, and raccoon *(Procyon lotor),* which is often seen in the IA OU and near watercourses. Typically at RFETS, three to six coyote dens support an estimated 14 to 16 individuals at any given time (K-H, 2001).

Twenty-two coyote dens used between 1991 and 2002 have been identified at RFETS. The coyote dens generally occur on hillsides near watercourses. Six dens were active in 2002. One active den was located in the upper Rock Creek drainage, two were located on the slopes above either side of Walnut Creek near Indiana Street, one was near Pond D-1, one was near Antelope Springs, and one was in the upper South Woman Creek drainage (Nelson 2003). Other carnivores include striped skunk *(Mephitis mephitis),* gray fox *(Urocyon cinereoargenteus),* red fox *(Vulpes vulpes),* long-tailed weasel *(Mustela frenata),* American badger *(Taxidea taxus),* and mink *(Mustela vison).* Black bear *(Ursus americanus)* and mountain lion *(Felis concolor)* tracks are occasionally seen at the site (K-H, 2000, 2001).

9.2.1.1 Black-Tailed Prairie Dog

The black-tailed prairie dog is a controversial species in terms of U.S. conservation activities (CDOW 2003). The prairie dog is often described and disputed as a "keystone species" because it has a large effect on community structure or ecosystem function (Power et al. 1996, CDOW 2003).

In August 2004, FWS removed the prairie dog from consideration as a candidate species under the ESA (FWS 2004b). Candidate species are plants and animals for which FWS has sufficient information on their biological status to propose them as endangered or threatened under the ESA, but for which development of a proposed listing regulation is precluded by other higher-priority listing activities. Candidate species receive no statutory protection under the ESA (FWS 2002).

Regardless of its status as a keystone species, prairie dogs play an important role in grassland ecosystems. Several studies found that prairie dogs alter plant species' composition and structure. Typically, areas occupied by prairie dogs have greater cover and abundance of perennial grasses and annual forbs compared to nonoccupied sites (Whicker and Detling 1988, Witmer et al. 2002). Prairie dogs can contribute to overall landscape heterogeneity, affect nutrient cycling, and provide nest sites and shelter for wildlife such as rattlesnakes and burrowing owls (Whicker and Detling 1988). However, prairie dogs can also denude the surface by clipping aboveground vegetation and contributing to exposed bare ground by digging up roots (Kuford 1958, Smith 1967) and are susceptible to and can spread Sylvatic plague.

Three black-tailed prairie dog colonies, comprising 112.8 acres of grasslands, were mapped at RFETS in 2000. Mapping conducted in 2002 shows a smaller area of colonies (Figure 24): this reflects plague outbreaks since 2000 that eventually reduced the active colonies to an area of approximately 10 acres (Stone 2003). The site contains approximately 2,460 acres of potential prairie dog habitat based on the following soil, vegetation, and slope attributes that prairie dogs are known to prefer (Clippinger 1989):

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- 30- to 90-percent herbaceous cover;
- 2- to 10-inch vegetation height;
- Slopes less than 20 percent (prefer less than 10 percent); and
- Rock-free soils with less than 70 percent sand content.

9.2.2 Birds

The most commonly observed raptors at RFETS are the red-tailed hawk *(Buteo jamaicensis),* great horned owl *(Bubo virginianus),* and American kestrel *(Falco sparverius).* Other less abundant raptors include Swainson's hawk *(Buteo swainsoni),* ferruginous hawk *(Buteo regalis),* prairie falcon *(Falco mexicanus),* and long-eared owl *(Asio otus).* Most raptor species use riparian woodlands or tall upland shrublands for nesting and roosting habitat and forage in all habitats at the site.

Over 185 species of migratory birds have been recorded at RFETS, of which approximately 75 are believed to breed at the site. Of the estimated 100 neotropical migrants (migratory birds that breed north of the U.S./Mexico border and winter south of the border) (PTI 1997), approximately 45 are confirmed or suspected breeders at the site.

Commonly observed bird species in wetland habitats include the red-winged blackbird *(Agelaius phoeniceus),* song sparrow *(Melospiza melodia),* common yellowthroat *(Geothlypis trichas),* and common snipe *(Gallinago gallinago).* Common birds in riparian woodland areas include the northern oriole *(Icterus galbula),* American goldfinch *(Carduelis tristis),* house finch *(Carpodacus mexicanus),* and yellow warbler *(Dendroica petechia).* The tall upland shrubland habitat is inhabited by the song sparrow, rufus-sided towhee *(Pipilo maculatus*), black-billed magpie *(Pica hudsonia),* yellow-breasted chat *(Icteria virens)* and black-capped chickadee *(Poecile atricapilla).* Common grassland birds include the vesper sparrow *(Pooecetes gramineus),* western meadowlark *(Sturnella neglecta),* grasshopper sparrow (*Ammodramus savannarum*), and mourning dove *(Zenaida macroura)* (DOE 1997). The reclaimed mixed grassland provides habitat for birds such as the western meadowlark and vesper sparrow (PTI 1997).

Several waterfowl species use the RFETS ponds. The most common waterfowl are mallards *(Anas platyrhynchos)* and Canada geese *(Branta canadensis)* (DOE 1997). Great blue herons *(Ardea herodias)* feed in mudflats and short marshlands, while double-crested cormorants *(Phalacrocorax auritus)* are common summer residents.

9.2.2.1 Plains Sharp-Tailed Grouse

The site and surrounding areas contain potential habitat for the plains sharp-tailed grouse *(Tympanuchus phasianellus)*. The grouse is not known to have occurred at RFETS prior to 2003 (DOE 1997). The City of Boulder Open Space and Mountain Parks Department, along with Boulder County Parks and Open Space and CDOW, have initiated a sharp-tailed grouse reintroduction program on joint City/County-owned open space land north of the site. Approximately 25 individuals were transplanted to the open space area in 2003, while several more are planned to be reintroduced in the future (Brennan 2003). Several of the transplanted individuals are believed to have used RFETS grasslands (Wedermyer 2003).

According to the CDOW Plains Sharp-Tailed Grouse Recovery Plan (CDOW 1992), grouse use different habitats seasonally with extensive use of grassland and grassland-low shrub transition zones. Riparian areas and wooded draws are important winter habitat. Reasons for the decline of sharp-tailed grouse include land cultivation, livestock grazing, and fire control. Other threats to grouse include urban development and alteration of habitat by weed infestation (Gershman 1992).

9.2.3 Reptiles and Amphibians

In general, reptiles and amphibians are found in small numbers at the site due to an absence of suitable habitat. The most common reptiles are the bullsnake *(Pituophis melanoleucus)*, yellow-bellied racer *(Coluber constrictor)*, plains garter snake *(Thamnophis radix)*, and prairie rattlesnake *(Crotalus viridis)*. All of these species occur in the open grassland habitats, although the plains garter snake typically lives close to water bodies. Other reptiles include the short-horned lizard (*Phynosoma douglassi)* in open grasslands and the western painted turtle *(Chrysemys picta)* in ponds (DOE 1997).

The most abundant amphibian at RFETS is the boreal chorus frog *(Pseudacris triseriatus maculata),* which breeds in water bodies throughout the site. The northern leopard frog *(Rana pipiens)* is less common and is found only in permanent water bodies such as ponds (DOE 1997). The boreal chorus frog is relatively abundant in the streams and wetlands at Rocky Flats (K-H 2000). Other amphibians include the bullfrog *(Rana catesbeiana),* Woodhouse's toad *(Bufo woodhousii),* plains spadefoot *(Spea bombifrons),* and tiger salamander (*Ambystoma tigrinum)* (DOE 1997).

9.2.4 Aquatic Species

Aquatic species at RFETS are limited in drainages and ditches by low and irregular flows. The most common aquatic macroinvertebrates (aquatic insects) are larvae of the blackfly (Order *Diptera, Simulidae* sp.), midge (Order *Diptera, Chironomidae* sp) and mayfly (Order *Ephemeroptera*) (DOE 1997). Other species include caddisflies (Order *Trichoptera*), craneflies (*Tipulidae* ssp.), and damselfly larvae (Order *Odonata*), as well as snails (Class *Gastropoda*) and amphipods (Order *Amphipoda*). Large macroinvertebrates such as crayfish (Order *Decapoda*, Family *Astacidae*) and snails are potentially important prey for other fish, waterfowl, and mammal species.

Each of the primary drainages at the site contains a variety of pond and stream habitats, varying amounts of habitat modification, and seasonal water flows. The Walnut Creek drainage has been highly modified as part of the development of RFETS. The upper section of the drainage was filled and the lower section modified into a series of small reservoirs that can retain water released from the IA. A variety of non-native fish species (rainbow trout [*Salmo gairdneri*], carp [*Cyprinus carpio*], bass [Order *Centrarchidae, Micropterus* sp.]) were introduced into the Walnut Creek reservoirs. Although all introductions did not establish reproducing fish populations, carp, goldfish *(Carassius auratus),* and fathead minnows *(Pimephales promelas)* are present in these reservoirs. Woman Creek retains a significant amount of stream habitat and holds the majority of RFETS fish species. Native fish species that reproduce within Woman Creek include white suckers *(Catostomus commersoni),* fathead minnows, green sunfish *(Lepomis cyanellus*), stonerollers *(Campostoma anomalum*), and creek chubs *(Semotilus atromaculatus*). Two non-native fish species, golden shiners *(Notemigonus crysoleucas)* and largemouth bass *(Micropterus salmoides),* also are found in the drainage.

According to the Colorado Vertebrate Ranking System (CDOW, 2001), the Iowa darter *(Etheostoma exile*) and common shiner (*Luxilus cornutus*) rank high enough to merit re-evaluation, and the redbelly dace *(Phoxinus eos*) is potentially imperiled. Threats to these species include extirpation through habitat degradation (such as siltation, pollution, and/or bank destabilization), effects of urbanization, and predation by introduced non-native fish.

9.2.4.1 Native Fish Restoration

The 2001 Rock Creek Reserve Integrated Natural Resources Management Plan (DOE/FWS 2001) called for the establishment of native fish populations within the Rock Creek drainage. Rock Creek supports favorable habitat for native fish such as the common shiner and northern redbelly dace. Monitoring during the drought of 2002 demonstrated that Rock Creek flows remain consistent in dry years.

Native fish restoration efforts began in 2002, when largemouth bass *(Micropterus salmoides)* and other non-native fish were removed from the Lindsay Ponds with rotenone (a piscicide). In June and August 2003, common shiner and northern redbelly dace were introduced to the Rock Creek drainage, with the intention of establishing a new population of these rare and declining native fish species (Rosenlund 2003).

9.2.5 Wildlife Species of Special Concern

In addition to federally listed wildlife species described in Section 9.3, RFETS has been known to support numerous species with special status designated by CDOW because of their rare or imperiled status. The western burrowing owl *(Athene cunicularia*) has been observed in grasslands, and the ferruginous hawk has been observed in riparian woodlands and open grasslands (PTI 1997, DOE 1997).

9.2.6 Wildlife Corridors

While RFETS is surrounded on three sides by major roads, many wildlife species move between the site and habitat in surrounding areas. However, movement corridors between the site and adjacent lands are not well defined. Movement of most terrestrial species occurs along broad areas where disturbance and barriers to movement are minimized (Howard 2003; Wedermyer 2003).

On the western side of RFETS, east-west movement across Highway 93 can be impeded by the South Boulder Diversion Canal and mining areas. Given these barriers, the most likely areas for wildlife movement are the open lands in the upper Rock Creek and upper Woman Creek areas between the mining areas (on land owned by the State of Colorado) and the West Access Road.

Prairie dogs cross Highway 128 in the northeastern corner of RFETS, to access other colonies on adjacent open space lands. Otherwise, north-south prairie dog movement across Highway 128 does not likely occur at any specific location. The Rock Creek drainage along the highway is impeded by the highway embankment and the culverts for the creek are too small for use by larger species of mammals. Likewise, the eastern portion of the site is open in most places and wildlife moves across a broad front, although the Walnut Creek and Woman Creek drainages provide natural corridors for east-west movement for small and mid-size mammals across Indiana Street.

Most deer on RFETS do not migrate off site and elk periodically descend from the foothills and enter RFETS from the west. In spring of 2003, several cow elk used the Rock Creek drainage as a calving ground (Wedermyer 2003). The behavior of other species is less known.

9.2.7 Potential Effects of Contamination on Wildlife and Vegetation

Extensive studies have been conducted since the mid-1970s, primarily by Colorado State University (CSU) researchers, on potential effects of contamination on RFETS wildlife and vegetation (Geiger and Winsor 1977, Bly and Whicker 1979, Little et al. 1980, Symonds and Alldredge 1992). These studies include two deer studies as well as studies of small mammals, arthropods (insects), snakes, and cattle. Samples were taken of various species for the Draft Ecological Risk Assessments for Walnut Creek and Woman Creek Watersheds at RFETS (September 1995) and included samples consisting of small mammals, insects, benthic invertebrates, and fish. Additional studies were conducted by CSU researchers on vegetation uptake of plutonium in both terrestrial and aquatic species (Paine 1980, Arthur and Alldredge 1982).

Tissue samples, including edible tissues of deer harvested at RFETS in 2002, have been analyzed for contaminants. The results of these analyses indicate radionuclide tissue levels of nondetectable quantities or at method detection limits. In all cases the edible tissue levels are below the risk-based level for consumption of RFETS deer tissue (Todd and Sattelberg 2004).

9.3 Federal Threatened and Endangered Species

The site supports one wildlife species, the PMJM, listed as threatened or endangered under the ESA. In addition to the PMJM, bald eagles occasionally forage at the site. Both the PMJM and bald eagle are listed as threatened. As discussed in Section 9.2.1.1, the black-tailed prairie dog is no longer listed as a candidate species (FWS 2004b).

9.3.1 Preble's Meadow Jumping Mouse

The PMJM occurs in every major drainage on the site (Figure 25). Listed as a threatened species in 1998, the PMJM occurs in habitat adjacent to streams and waterways along the Front Range of Colorado and southeastern Wyoming. At RFETS, the PMJM also has been found in wetlands and shrubland communities adjacent to the Rock Creek and Woman Creek drainages. Knowledge of the natural history and ecology of the PMJM is limited. An increase in knowledge about the species may change our understanding of their habitat needs and associations. In 2003, FWS designated critical habitat for the PMJM. The critical habitat did not include any of the drainages at RFETS because the site is to become a Refuge (FWS 2003).

In March 2004, FWS initiated a status review of the PMJM based on two petitions to remove the mouse from federal protection under the ESA. When the status review is finished, FWS will issue a finding regarding whether the subspecies should remain listed or should be proposed for delisting (FWS 2004c). However, until the status review and finding are finalized, FWS will continue to manage the PMJM as a threatened species in accordance with existing laws and policies, and the Comprehensive Risk Assessment (CRA) will address the PMJM separately from all other wildlife receptors.

9.3.2 Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) occasionally forages at RFETS although no nests have been identified. An active nest is located east of the site near Standley Lake. Eagles feed primarily on fish and waterbirds but also on small mammals and mammal carcasses (DOE/FWS 2001). The bald eagle was federally listed as endangered in 1967 and was downlisted to threatened in 1994.

9.3.3 Plant Species

No federally-listed plant species are known to occur at RFETS. While many of the riparian and wetland communities support potential habitat for the Ute ladies'-tresses orchid and Colorado butterfly plant, these species are not known to occur at the site (ESCO 1994). Vegetation at RFETS includes several rare and sensitive plant communities. These include the xeric tallgrass grassland, tall upland shrubland, riparian shrubland, mountain-loving sedge, forktip three-awn, carrionflower greenbriar, dwarf wild indigo, and plains cottonwood riparian woodland communities. Each of these communities is described in detail in Section 9.1.

10.0 REFERENCES

AeroVironment, 1995, Rocky Flats Environmental Technology Site Historical Data Summary, (AV-R-9308-200), AeroVironment, Inc. February.

Arthur, W.J and A.W. Alldredge, 1982, "Importance of Plutonium Contamination on Vegetation Surfaces at Rocky Flats, Colorado," *Environmental and Experimental Botany*, Vol. 22, No. 1, pp. 33-38.

Blatt, H., G. Middleton, and R. Murray, 1980, *Origin of Sedimentary Rocks*, Prentice Hall, Inc., Englewood Cliffs, New Jersey.

Bly, J.A. and F.W. Whicker, 1979, *Plutonium Concentrations in Arthropods at a Nuclear Facility. Health Physics*, Pergamon Press, Vol. 37, pp. 331-336.

Brennan, M., 2003, Boulder County Parks and Open Space Department. Personal communication with Ron Beane, ERO Resources, April 16, 2003 (as referenced in the Rocky Flats National Wildlife Refuge Final Comprehensive Conservation Plan and Environmental Impact Statement, September 2004).

CDOW, 1992, Plains Sharp-Tailed Grouse Recovery Plan, Colorado Division of Wildlife.

CDOW, 2001, Colorado Vertebrate Ranking System (COVERS) database, Colorado Division of Wildlife, ftp:/www.NDIS.NREL.colostate.edu/.

CDOW, 2003, Grassland Species Conservation Plan, Colorado Division of Wildlife.

CH2M-Hill, 1996, Final Construction Report for the Woman Creek Dam and Reservoir Project, Prepared by CH2M Hill, February.

Clippinger, N., 1989, Habitat suitability index models: black tailed prairie dog. Biological Report 82 (10.156): 1-21, U.S. Fish and Wildlife Research and Development, Washington, D.C.

CNHP, 1994, Natural Heritage Resources of the Rocky Flats Environmental Technology Site and Their Conservation. Phase 1: Rock Creek. Final Report. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

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CNHP, 1995, Natural Heritage Resources of the Rocky Flats Environmental Technology Site and Their Conservation. Phase 2: the Buffer Zone. Final Report. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

DOE, 1997, Rocky Flats Cumulative Impacts Document, Rocky Flats Field Office, Rocky Flats Environmental Technology Site, Golden, Colorado.

DOE, 1998, Historic American Engineering Record (HAER) Survey No. CO-83, A-Z, AA-AI, Submitted to the HAER on June 1, 1998.

DOE, 1999, Vegetation Management Environmental Assessment, Rocky Flats Field Office.

DOE, 2000, Natural Resource Management Policy, U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, Colorado.

DOE, 2002, Final Work Plan for the Development of the Remedial Investigation and Feasibility Study Report, Rocky Flats Environmental Technology Site, Golden, Colorado.

DOE, 2004, Environmental Assessment Comment Response and Finding of No Significant Impact, Pond and Land Configuration, DOE/EA – 1492, U.S. Department of Energy, Rocky Flats Project Office, Golden, Colorado, October.

DOE/FWS, 2001, Integrated Natural Resources Management Plan, Environmental Assessment and Finding of No Significant Impacts for Rock Creek Reserve, 2001-Closure, U.S. Department of Energy/U.S. Fish and Wildlife Service.

DRCOG, 2004, Summary Population and Household Forecasts. Denver Regional Council of Governments, Metro Vision Resource Center. Denver, Colorado. Available via the DRCOG website: http://www.drcog.org/MVRC/socio.html.

EG&G, 1991, Geologic Characterization Report, EG&G Rocky Flats, Inc., Rocky Flats Plant, Golden, Colorado.

EG&G, 1993, Background Geochemical Characterization Report Rocky Flats Plant, EG&G Rocky Flats, Inc., Rocky Flats Plant, Golden, Colorado. September.

EG&G, 1995a, Geologic Characterization Report for the Rocky Flats Environmental Technology Site, Vol. 1, EG&G Rocky Flats, Inc., Rocky Flats Environmental Technology Site, Golden, Colorado, March.

EG&G, 1995b, Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site, Volume II of the Sitewide Geoscience Characterization Study, EG&G Rocky Flats, Inc., Rocky Flats Environmental Technology Site, Golden, Colorado, April.

EG&G, 1995c, Geochemical Characterization of Background Surface Soils: Background Soil Characterization Program, Rocky Flats Environmental Technology Site, EG&G Rocky Flats, Inc., Golden, Colorado, May.

EG&G, 1995d, Groundwater Geochemistry Report for the Rocky Flats Environmental Technology Site, Volume III of the Sitewide Geoscience Characterization Study, January.

ESCO, 1994, Report of Findings: Ute Ladies'-Tresses and Colorado Butterfly Weed Surveys, Rocky Flats Buffer Zone, Jefferson County, Colorado.

ESCO, 2002, Draft Report of Findings: Five-Year Study of the Ecology of Bluestem-Dominated Grasslands of the Rocky Flats Area, 1996-2001, Jefferson and Boulder Counties, Colorado.

Essington, K.D, S.M. Kettler, S.E. Simonson, C.A. Pague, J.S. Sanderson, P.M. Pined and A.R. Ellingson, 1996, Natural Heritage Resources of the Rocky Flats Environmental Technology Site and Their Conservation, Phase II: The Buffer Zone, Colorado Natural Heritage Program, Fort Collins, Colorado.

FWS, 2002, Candidate Conservation Program, U.S. Fish and Wildlife Service, http://endangered.fws.gov/candidates/index.html.

FWS, 2003, Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Preble's Meadow Jumping Mouse (Zapus hudsonius preblei), U.S. Fish and Wildlife Service, Federal Register, 68: 37276-37332, June 23.

FWS, 2004a, Rocky Flats National Wildlife Refuge, Final Comprehensive Conservation Plan and Environmental Impact Statement, U.S. Fish and Wildlife Service, September.

FWS, 2004b, Endangered and Threatened Wildlife and Plants; Finding for the Resubmitted Petition to List the Black-Tailed Prairie Dog as Threatened; U.S. Fish and Wildlife Service, Federal Register, 69: 51217-51226.

FWS, 2004c, Endangered and Threatened Wildlife and Plants; 90-Day Finding for a Petition to Delist the Preble's Meadow Jumping Mouse in Colorado and Wyoming and Initiation of a 5-Year Review; U.S. Fish and Wildlife Service, Federal Register, 69: 16944-16946, March 31.

Geiger, R.G. and T.F. Winsor, 1977, "239Pu Contamination in Snakes Inhabiting the Rocky Flats Plant Site", *Health Physics*, Pergamon Press, Vol. 33, pp. 145-148, August.

Gershman, M., 1992, Comment letter (on the CCP) from Mark Gershman, City of Boulder Open Space to Clait Broun (CDOW) on the Draft Plains Sharp-Tailed Grouse Recovery Plan, January.

Haun, J.D. and H.C. Kent, 1965, "Geologic History of the Rocky Mountain Region". *Bull. of the American Association of Petroleum Geologists*, v 49, no. 11, p. 1781-1800.

Howard, T., 2003, District Wildlife Manager, Colorado Division of Wildlife. Personal communication with Ron Beane, ERO Resources Corporatiion, July 3, 2003.

Hurr, R.T., 1976, Hydrology of a Nuclear-Processing Plant Site, Rocky Flats, Jefferson County, Colorado, United States Geological Survey Open-File Report 76-268, 68 pp.

K-H, 1997, Metadata report accompanying veg96b.shp GIS data showing land cover-data derived from 1995 – 1996 field surveys, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 2000, 1999 Annual Wildlife Survey for the Rocky Flats Environmental Technology Site, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 2001, 2000 Annual Wildlife Survey for the Rocky Flats Environmental Technology Site. Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 2002a, Site-Wide Water Balance Modeling Report for the Rocky Flats Environmental Technology Site, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 2002b, Final 2001 Annual Rocky Flats Cleanup Agreement Groundwater Monitoring Report for the Rocky Flats Environmental Technology Site, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 2002c, 2001 Annual Vegetation Report for the Rocky Flats Environmental Technology Site, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 2002d, 2002 Annual Vegetation Management Plan for the Rocky Flats Environmental Technology Site, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 2004a, Land Configuration Design Basis Project, Industrial Area Grading and Drainage Plans, Engineered Channels, December 22, 2004 Draft Issued for Construction Submittal,.Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 2004b, Interim Measure/Interim Remedial Action for the Original Landfill (Including IHSS Group SW-2; IHSS 115, Original Landfill and IHSS 196, Filter Backwash Pond), Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 2004c, Interim Measure/Interim Remedial Action and Closure Plan for the Present Landfill. Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

Kettler, S.M., S.E. Simonson, C.A. Pague, A. R. Ellingson. 1994, Significant Natural Heritage Resources of the Rocky Flats Environmental Technology Site and Their Conservation: Phase I: The Rock Creek Drainage. Colorado Natural Heritage Program, Fort Collins, Colorado.

Kuford, C.C., 1958, Prairie dogs, Whitefaces and Blue Grama, Wildlife Monograph 1-78.

Lane, E. 2004, State Weed Coordinator, Colorado Department of Agriculture, Information provided in comments to Draft CCP/EIS, April 26.

Leroy, L.W. and R.J. Weimer, 1971, Geology of the Interstate 70 Road Cut, Jefferson County Colorado: Colorado School of Mines Professional Contribution No. 7.

Little, C.A, F.W. Whicker and T.F. Winsor, 1980, "Plutonium in a Grassland Ecosystem at Rocky Flats," *Journal of Environmental Quality*, Vol. 9, No. 3, pp. 350-354.

Nelson, J., 2003, Senior Ecologist, Kaiser-Hill Ecology Group. Rocky Flats Environmental Technology Site. Personal communication with Bill Mangle, ERO Resources. January 14.

Paine, D., 1980, "Plutonium in Rocky Flats Freshwater Systems," In *Transuranic Elements in the Environment; A Summary of Environmental Research on Transuranium Radionuclides* funded by the U.S. Department of Energy through Calendar Year 1979, W.C. Hanson, Editor, DOE/TIC-22800, Technical Information Center, U.S. Department of Energy.

Power, M.E., D. Tilman, J.A. Estes, B.A. Menge, W.T. Bond, L.S. Mills, G. Daily, J.C. Castilla, J. Lutchonco and R.T. Paine, 1996, "Challenges in the Quest for Keystone Species," *BioScience* 46:609-620.

Price, A.B. and A.E. Amen. 1983, Soil Survey of the Golden Area, Colorado – Parts of Denver, Douglas, Jefferson, and Park Counties: U.S. Department of Agriculture, Soil Conservation Service.

PTI, 1997, Ecological Resource Management Plan for the Rocky Flats Environmental Technology Site, PTI Environmental Services, Prepared for Kaiser-Hill, LLC., Rocky Flats Environmental Technology Site, Golden, Colorado.

Rockwell, 1988, Resource Conservation and Recovery Act Post-Closure Care Permit, Vol. 6, App. 6 Section 5 and Section 3, Rockwell International, October.

Rosenlund, B. 2003, Draft paper on native fish restoration, U.S Fish & Wildlife Service.

RMRS, 1996, White Paper: Analysis of Vertical Contaminant Migration Potential. Rocky Mountain Remediation Services, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado, August.

RMRS/DOE, 1995, Rocky Flats RFI/RI OU3 (General Report), Section 3.3 (Draft) Golden, Colorado, August.

SAIC, 1996, Final Draft Cultural Resource Management Plan: Rocky Flats Environmental Technology Site, Prepared by Science Applications International Corporation for the DOE Rocky Flats Field Office, Golden, Colorado, March 29, 1996.

Smith, R.E. 1967, Natural History of the Prairie Dog in Kansas, University of Kansas Museum of Natural History Misc. Publication No. 49.

Spencer, 1961, Bedrock Geology of the Louisville Quadrangle, Colorado. U.S. Geological Survey, Geological Quadrangle Map GQ-151.

Stone, E. 2004, Biologist, U.S. Fish & Wildlife Service, Personal communication with Bill Mangle, ERO Resources, January 5 (as referenced in the Rocky Flats National Wildlife Refuge Final Comprehensive Conservation Plan and Environmental Impact Statement, September 2004).

Symonds, K.K. and A.W. Alldredge, 1992, Deer Ecology Studies at Rocky Flats, Colorado; 1992-1992 progress report, Agreement ASC 49074 and ASC 77313AM, Colorado State University, Ft. Collins, Colorado.

Todd, A. and M. Sattelberg, 2004, Actinides in Deer Tissues at the Rocky Flats Environmental Technology Site. U.S. Fish and Wildlife Service, 2004.

UDFCD, 2001, Urban Storm Drainage Criteria Manual, Volume 1, Urban Drainage and Flood Control District, Denver, Colorado, June.

USACE, 1994, Rocky Flats Plant Wetland Mapping and Resource Study (prepared for U.S. Department of Energy), U.S. Army Corps of Engineers, Omaha District, December.

USGS, 1996, Surficial Geologic Map of the Rocky Flats Environmental Technology Site and Vicinity, Jefferson and Boulder Counties, Colorado, U.S. Geological Survey.

USGS, 2002, USGS Earthquakes Hazard Program, National Seismic Mapping Project. http://eqhazmaps.usgs.gov.

Wedermyer, M., 2003, District Wildlife Manager, Colorado Division of Wildlife. Personal communication with Ron Beane, ERO Resources Corporation, July 1.

Weimer, R.J., 1973, A guide to Uppermost Cretaceous stratigraphy, central Front Range, Colorado: Deltaic sedimentation, growth faulting and early Laramide crustal movement: The Rocky Mountain Geologist, Rocky Mountain Association of Geologists, v. 10, p. 53-97.

Whicker, A.D. and J.K. Detling, 1988, "Ecological Consequences of Prairie Dog Disturbances." *BioScience*, 38:778- 785.

Witmer, G.W., K.C. VerCauteren, K.M. Manci, and D.M. Dees, 2002, Urban-suburban prairie dog management opportunities and challenges. Proceedings of 19th Vertebrate Pest Conference. 19:439-444.

Table 1. Man-Made Structures That Remain Below Grade Level

(sample table – this will need to be completed with input from DOE. Goes along with Figure 4)

Building/Area	Subsurface Structure That Remains
Building 444 site	Basement walls and slab
Building 707 site	Foundation, etc.
Building 771 site	Basement walls and slab
Building 881 site	Basement walls and slab
Building 991 site	Basement walls and slab
IA OU – 900 area	culvert

Table needs to be expanded.

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Table 2. Summary of Geotechnical Properties of Soil and Overburden

Soil Name	Sample Depth (inches)	Unified Soil Classification[1]	Percentage Passing Sieve Number				Liquid Limit	Plasticity Index	Permeability (inches/hr)	Available Water Capacity (inches/inch)
			4	10	40	200				
Flatirons	0 – 13	GM, SM	40 – 80	35 – 70	20 – 45	10 – 30	15 – 25	0 – 5	2.0 – 6.0	0.07 – 0.10
	13 – 47	GC	40 – 60	35 – 55	30 – 50	25 – 40	35 – 60	20 – 50	0.06 – 0.2	0.08 – 0.10
	47 – 60	GC	40 – 60	35 – 55	30 – 50	15 – 30	25 – 35	10 – 20	0.6 – 2.0	0.08 – 0.10
Nederland	0 – 10	SM-SC	70 – 90	70 – 85	40 – 55	25 – 35	20 – 30	5 – 10	2.0 – 6.0	0.10 – 0.12
	10 – 62	SC	70 – 90	70 – 90	40 – 65	25 – 50	30 – 40	10 – 20	0.6 – 2.0	0.08 – 0.12
	62 – 70	SM-SC, SC	65 – 80	60 – 80	30 – 50	20 – 30	20 – 35	5 – 15	---	---
Denver	0 – 6	CL	95 – 100	90 – 100	75 – 100	70 – 90	30 – 50	10 – 25	0.2 – 0.6	0.16 – 0.20
	6 – 29	CH-CL	95 – 100	95 – 100	90 – 100	85 – 100	40 – 75	20 – 45	0.06 – 0.2	0.14 – 0.18
	29 – 60	CL, CH	95 – 100	90 – 100	80 – 100	75 – 95	35 – 60	15 – 30	0.06 – 0.6	0.014 – 0.18
Kutch	0 – 3	CL	95 – 100	90 – 100	90 – 100	70 – 80	30 – 50	15 – 30	0.2 – 0.6	0.15 – 0.20
	3 – 26	CH, CL	95 – 100	90 – 100	90 – 100	75 – 95	45 – 60	20 – 35	0.06 – 0.2	0.18 – 0.20
Midway	0 – 3	CL	75 – 100	75 – 100	70 – 100	70 – 95	30 – 40	10 – 20	0.2 – 0.6	0.14 – 0.18
	3 – 14	CL, CH	95 – 100	95 – 100	90 – 100	70 – 95	35 – 60	20 – 35	0.06 – 0.2	0.14 – 0.18
Haverson	0 – 6	ML	95 – 100	90 – 100	85 – 100	55 – 70	25 – 35	0 – 10	0.6 – 2.0	0.14 – 0.18
	6 – 46	CL, CL-ML	95 – 100	85 – 100	70 – 95	50 – 70	25 – 40	5 – 15	0.2 – 0.6	0.14 – 0.18
	46 – 60	GM, SM	35 – 55	30 – 50	20 – 40	5 – 15	---	0	0.2 – 0.6	0.04 – 0.06

Source: Price and Amen (1983)

Notes:
GM = Silty-gravels, gravel-sand-silt mixtures
SM = Silty sands, sand-silt mixtures
GC = Clayey gravels, gravel-sand-clay mixtures
SC = Clayey sands, sand-clay mixtures
CL = Inorganic clays of low to medium plasticity, gravelly/sandy/silt/lean clays
CH = Inorganic clays or high plasticity, fat clays
ML = Inorganic silts, very fine sands, rock four, silty or clayey fine sands

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Table 3. Flow Data at Select Gaging Stations – Site Configuration During Accelerated Actions

Drainage	Tributary	Gaging Station	Mean Annual Discharge Volume (ac-ft)	Dates of Record	Peak Flow Rate (cfs) (15-min record)	Date of Peak Flow
Rock Creek	-	GS04	240.7	10/1/96-9/30/04	35.4	3/26/03
Walnut Creek	McKay Ditch	GS35	69.3	10/1/97-9/30/04	23.6	3/26/03
	No Name Gulch	GS33	17.2	10/1/97-9/30/04	6.8	5/1/99
	N. Walnut Creek	SW093	149.9	10/1/96-9/30/04	134.9	7/14/01
	S. Walnut Creek	GS10	102.7	10/1/96-930/04	112.6	8/27/00
	Entire Watershed	GS03	453.1	10/1/96-9/30/04	56.5	3/26/03
Woman Creek	S. Interceptor Ditch	SW027	22.8	10/1/96-9/30/04	10.2	8/27/00
	N. Woman Creek	GS05	109.1	10/1/96-9/30/04	24.7	4/4/98
	Owl Branch	GS06	20.6	10/1/96-9/30/04	12.1	4/27/97
	Antelope Springs	GS16	95.5	10/1/96-9/30/04	8.6	4/4/98
	Entire Watershed	GS01	269.1	10/1/96-9/30/04	79.5	4/30/99

Table 4. Summary Table – Retention Ponds Characteristics

Drainage	Pond	Capacity (acre-feet)	Dam Characteristics	Inflow From:	Outflow To:	Function	Pond Operating Protocol
North Walnut Creek	A-1	To be determined in new config.	- Earthen dam - notched with stoplog outlet structure - Not keyed into firm foundation rock - No toe/interior drain	N. Walnut Ck.	Pond A-2	Sustain wetlands, minor flow attenuation, and settling of suspended solids	Flow-through
	A-2	To be determined in new config.	- Earthen dam - notched with stoplog outlet structure - Keyed into firm foundation rock -Toe/interior drain	Pond A-1	Pond A-3	Sustain wetlands, minor flow attenuation, and settling of suspended solids	Flow-through
	A-3	38.0	- Earthen dam - Keyed into firm foundation rock -Toe/interior drain - Outlet works	N. Walnut Bypass <u>or</u> Pond A-2	Pond A-4	Sustain wetlands, minor flow attenuation, and settling of suspended solids	Batch-release (released through outlet works when pool level reaches approx. 50% of capacity)
	A-4	99.7	- Earthen dam - Keyed into firm foundation rock - No toe/interior drain - Outlet works with standpipe inlet	Pond A-3	N. Walnut Creek	Sustain wetlands, storm flow storage, and settling of suspended solids	Batch-release (released through outlet works when pool level reaches approx. 50% of capacity)

(table continued)

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Table 4 (continued)

Drainage	Pond	Capacity (ac-ft)	Dam Characteristics	Inflow From	Outflow To	Function	Pond Operating Protocol
South Walnut Creek	B-1	To be determined in new config.	- Earthen dam - notched with stoplog outlet structure - Unknown if keyed into bedrock - Toe/interior drain	S. Walnut Creek	Pond B-2	Sustain wetlands, minor flow attenuation, and settling of suspended solids	Flow-through
	B-2	To be determined in new config.	- Earthen dam - notched with stoplog outlet structure - Unknown if keyed into bedrock - Toe/interior drain	Pond B-1	Pond B-3	Sustain wetlands, minor flow attenuation, and settling of suspended solids	Flow-through
	B-3	To be determined in new config.	- Earthen dam - notched with stoplog outlet structure - Unknown if keyed into bedrock - Toe/interior drain	Pond B-2	Pond B-4	Sustain wetlands, minor flow attenuation, and settling of suspended solids	Flow-through
	B-4	To be determined in new config.	- Earthen dam - notched with stoplog outlet structure - Unknown if keyed into bedrock - Toe/interior drain	S. Walnut Bypass <u>or</u> Pond B-3	Pond B-5	Sustain wetlands, minor flow attenuation, and settling of suspended solids	Flow-through
	B-5	73.6	- Earthen dam - Keyed into bedrock - Toe/interior drain - Outlet works with standpipe inlet	Pond B-4	S. Walnut Creek	Sustain wetlands, storm flow storage, and settling of suspended solids	Batch-release (released through outlet works when pool level reaches approx. 50% of capacity)

(table continued)

Table 4 (continued)

Drainage	Pond	Capacity (ac-ft)	Dam Characteristics	Inflow From	Outflow To	Function	Pond Operating Protocol
Woman Creek	C-1	To be determined in new config.	- Earthen dam - Unknown if keyed into bedrock - Toe/interior drain - No outlet works	Woman Creek	Woman Creek	Sustain wetlands, minor flow attenuation, and settling of suspended solids	Flow-through
	C-2	70.0	- Earthen dam - Keyed into bedrock - Toe/interior drain - Outlet works	South Interceptor Ditch	Woman Creek	Sustain wetlands, storm flow storage, and settling of suspended solids	Batch-release (released through outlet works when pool level reaches approx. 50% of capacity)
No Name Gulch	Landfill Pond	23.1	- Earthen dam - Unknown if keyed into bedrock - Toe/interior drain - Outlet works	Former Present Landfill area watershed	No Name Gulch	Sustain wetlands, minor flow attenuation, and settling of suspended solids	Flow-through via spillway or lower pond level via outlet works

Table 5. Surface Water Discharge Volumes - During and After Accelerated Actions

Drainage	Tributary	Gaging Station	During Accelerated Actions[1] (Measured Discharge)		After Accelerated Actions[2] (Model-Predicted Discharge)		
			Mean Annual Discharge Volume (ac-ft)	Dates of Record	Model Climate[3]	Predicted Annual Discharge Volume (ac-ft)[4]	Percent of Historic Mean Discharge Volume[4]
Walnut Creek	No Name Gulch	GS33	17.2	10/1/97 - 9/30/04	Typical[a]	-	-
					Wet year[b]	-	-
					Dry year[c]	-	-
	North Walnut Creek	SW093	149.9	10/1/96-9/30/04	Typical[a]	51.4	34%
					Wet year[b]	76.9	51%
					Dry year[c]	44.9	30%
	South Walnut Creek	GS10	102.7	10/1/96-9/30/04	Typical[a]	11.6	11%
					Wet year[b]	17.2	18%
					Dry year[c]	10.5	11%
	Entire Watershed	GS03	453.1	10/1/96-9/30/04	Typical[a]	55.9	12%
					Wet year[b]	124.8	28%
					Dry year[c]	49.5	11%

(table continued)

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(Table 5 continued)

Drainage	Tributary	Gaging Station	Measured During Accelerated Actions[1]		Model-Predicted After Accelerated Actions[2]		
			Mean Annual Discharge Volume (ac-ft)	Dates of Record	Model Climate[3]	Predicted Annual Discharge Volume (ac-ft)[4]	Percent of Historic Mean Discharge Volume[4]
Woman Creek	S. Interceptor Ditch	SW027	22.8	10/1/96-9/30/04	Typical[a]	1.6	7%
					Wet year[b]	3.2	14%
					Dry year[c]	1.3	6%
	Entire Watershed	GS01	269.1	10/1/96-9/30/04	Typical[a]	130.1	48%
					Wet year[b]	186.6	69%
					Dry year[c]	115.8	43%

Notes:

[1]Mean annual discharge during accelerated actions based on measured flow data.

[2]Mean annual discharge after accelerated actions based on MIKE SHE model simulations.

[3]Model climate: a) Typical = Water Year 2000 precipitation depth = 13.8 inches (compared to RFETS annual depth of 14.8 inches), b) Wet year simulation based on 19.4 inches annual precip. depth (Ft. Collins mean depth plus 1 standard deviation), c) Dry year simulation based on 11 inches annual precip. depth (Ft. Collins mean depth minus 1 standard deviation)

[4]Model-predicted values are subject to uncertainty. Model results are best utilized to evaluate relative changes observed in the RFETS hydrology resulting from changing watershed and/or climate conditions. Use of model predictions as absolute values for future changing conditions is not advised.

Table 6. Summary of Monthly Precipitation Data

Month	Precipitation – Water Equivalent (inches)		
	Monthly Mean	Monthly Maximum (Year)	Daily Maximum (Date)
January	0.40	1.12 (1974)	0.50 (1/12/72)
February	0.52	1.28 (1971)	0.70 (2/20/71)
March	1.18	4.70 (1970)	1.06 (3/30/70)
April	1.77	4.73 (1973)	2.30 (4/13/67)
May	2.65	9.70 (1969)	3.40 (5/6/69)
June	1.56	4.79 (1969)	2.94 (6/27/87)
July	1.47	5.10 (1965)	1.57 (7/16/00)
August	1.42	3.69 (1967)	2.10 (8/30/67)
September	1.48	4.53 (1976)	1.81 (9/26/76)
October	0.90	4.83 (1969)	1.83 (10/4/84)
November	0.79	2.00 (1972)	0.75 (11/1/72)
December	0.40	1.45 (1973)	0.50 (12/23/73)

Source: AeroVironment (1995) (1964 through 1977 and 1984 through 1993) and K-H precipitation data (1994 through 2004)

Table 7. Summary of Monthly Temperature Data

Month	Average Temperatures (°F)			Extreme Temperatures (°F)	
	Monthly Average Temperature	Highest Monthly Average Temperature (Year)	Lowest Monthly Average Temperature (Year)	Maximum Temperature (Date)	Minimum Temperature (Date)
January	32.9	40.2 (1986) [b/]	19.4 (1984)	69.7 (01/02/97)	-12.4 (01/12/97)
February	33.9	40.7 (1999)	22.9 (1964)	71.0 (02/28/72)	-9.3 (02/24/03)
March	38.7	46.5 (1972)	28.0 (1965)	82.0 (03/26/71)	-5.0 (03/25/65)
April	45.9	52.0 (1992)	38.4 (1973)	80.7 (04/30/92)	5.0 (04/09/73)
May	55.4	61.3 (1974)	48.0 (1969)	92.7 (05/29/00)	26.0 (05/01/70)
June	64.4	71.8 (1971)	58.9 (1969)	99.0 (06/23/71)	31.5 (06/05/98)
July	71.1	76.6 (2003)	66.1 (1992)	102.0 (07/12/71)	37.6 (07/17/75)
August	69.0	72.6 (1970)	64.6 (2004)	97.0 (08/08/69)	43.0 (08/28/04)
September	60.8	66.6 (1998)	53.2 (1965)	91.0 (09/10/74)	24.0 (09/19/71)
October	50.8	57.1 (1965)	38.8 (1969)	82.1 (10/16/91)	4.0 (10/14/69)
November	39.9	51.0 (1965)	30.7 (2000)	72.0 (11/25/70)	-3.3 (11/24/93)
December	33.7	39.7 (1976)	25.8 (1990)	72.0 (12/04/65)	-23.6 (12/21/90)
Extremes		**Highest Annual Average Temperature (°F)**	**Lowest Annual Average Temperature (°F)**	**Maximum Temperature (°F)**	**Minimum Temperature (°F)**
		52.5 (1988)	31.3 (1985)	102 (07/12/71)	-23.6 (12/21/90)

Source: AeroVironment (1995) (1964 through 1977 and 1984 through 1993) and K-H AIR database (1997 through 2004)

Table 8. Summary of Wind Speed Data

Month	Average Wind Speed (mph)[1]	Average Peak Wind Speed (mph)[2]
January	11.9	50.3
February	11.0	62.3
March	10.4	65.6
April	10.2	61.8
May	9.1	54.3
June	8.6	55.0
July	8.3	46.7
August	8.0	44.0
September	8.1	50.0
October	8.4	52.8
November	9.9	67.8
December	10.7	70.9
Annual Average	**9.5**	

Source: AeroVironment (1995) (1964 through 1977 and 1984 through 1993) and K-H AIR database (1997 through 2004)

Notes:

[1]Based on data collected from 1964 through 1977, 1984 through 1993, and 1997 through 2004

[2]Based on data collected from 1953 through 1977, 1984 through 1993, and 1997 through 2004

Table 9. Population and Households in Denver Metropolitan Area Counties

County	2000 Population[1] (Households)	2004 Population[2] (Households)
Adams	348,618 (127,299)	398,165 (148,889)
Arapahoe	487,967 (196,835)	524,414 (217,220)
Boulder	274,234 (113,464)	290,588 (121,483)
Broomfield	38,272 (14,322)	44,951 (17,268)
Clear Creek	9,322 (5,128)	9,607 (5,344)
Denver	554,636 (251,435)	572,862 (265,428)
Douglas	175,766 (63,333)	234,193 (85,966)
Gilpin	4,757 (2,929)	5,032 (3,213)
Jefferson	525,507 (211,916)	531,654 (220,619)
Region	**2,419,079** **(986,661)**	**2,611,466** **(1,085,430)**

Source: DRCOG (2004).

[1]Based on U.S. Census 2000
[2]Based on DRCOG estimate for Jan. 1, 2004

Table 10. List of Private Easement Holders

Reference No. in Figure 3	Easement/License Holder	Purpose	Recording Information (Jefferson County) Book/Page or Reception Numbers
1, 2, 3, 4	Industrial Gas Services, Inc.	Natural gas pipeline	(1)2530/987; (2)2531/801; (3)2534/289; (4)2521/438
5, 7, 8, 9	Colorado-Wyoming Gas Co.	Oil and gas pipelines	(5)1570/443; (7)771/9120; (8)1570/430; (9)1570/437
6	Western Slope Gas Co.	Gas pipeline	(6)Reception No.103793
10	No easement documentation	Believed to be occupied by a gas pipeline	No recording information available
11, 12, 13, 14, 15, 16, 17, 18, 20	Public Service Co. of Colorado	Electric power and transmission lines	(11)2211/438 and 2866/666; (12)1794/504 (warranty deed); (13)No recording information available; (14)1838/14; (15)1766/542; (16)1838/12; (17)750/379 and 857/553; (18)No easement documents created; (20)No recording information available
19	Public Service Co. of Colorado	Electric transmission line and access road	(19)No recording information available
21	Union Rural Electric Ass'n, Inc.	Electric transmission line and access driveways	(21)No recording information available
22	Perry McKay	Ingress/egress	(22)Reception No.87067103

(table continued)

(Table 10 continued)

Reference No. On Figure 3	Easement/License Holder	Purpose	Recording Information (Jefferson County) Book/Page or Reception Numbers
23	N/A (License to DOE from Denver and Rio Grande Western RR for telecommunications cable)	N/A	(23)No recording information available
24	N/A (License to DOE from Denver Water Board for bridge and road construction over ditch)	N/A	(24)No recording information available
25, 26	Mountain States Tel. & Tel.	Underground telecommunications cable	(25)1804/238; (26)No recording information available
27	City of Broomfield	McKay bypass pipeline for water conveyance	(27)No recording information available
28	No easement	Telecommunications cable	(28)N/A
29	No easement	Electric power line providing power to single residence on east side of Indiana Street, traffic lights at SH128/Indiana, SH128/McCaslin	(29)N/A
30	N/A (DOE-owned power line)	N/A	(30)N/A
31	N/A (DOE-owned right of way for water pipeline and railroad spur)	N/A	(31)N/A

Table 11. Vegetation Communities

Vegetation Community	Acres
Grasslands	
Xeric Tallgrass Grassland	1,568
Mesic Mixed Grassland	2,199
Xeric Needle and Thread Grassland	187
Reclaimed Mixed Grassland	640
Short Grassland	10
Shrublands	
Tall Upland Shrubland	34
Riparian Shrubland	41
Other Shrubland	70
Woodlands	
Riparian Woodland	28
Ponderosa Pine Woodland	9
Wetlands	
Tall Marsh Wetland	31
Short Marsh Wetland	121
Wet Meadow	254
Open Water/Mudflats	51
Other	
Disturbed and Developed Areas	997
Total	**6,240**

Source: Rocky Flats National Wildlife Refuge Final CCP and EIS (FWS 2004a)

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Table 12. Wetlands Inventory

Watershed	Stream Wetlands		Slope Wetlands		Total	
	Number	Acreage	Number	Acreage	Number	Acreage
Walnut Creek	300	40.0	43	8.1	343	48.1
Woman Creek	135	30.0	85	25.7	220	55.7
Rock Creek	163	25.4	152	32.2	315	57.6
Smart Ditch	204	28.2	17	1.4	221	29.6
Total	**802**	**123.6**	**297**	**67.4**	**1,099**	**191.0**

Source: Rocky Flats Plant Wetland Mapping and Resource Study (prepared for DOE), U.S. Army Corps of Engineers, Omaha District, December 1994 (USACE, 1994).

Table 13. Major Noxious Weeds Inventory

Weed Name	High Density (ac.)	Medium Density (ac.)	Low Density (ac.)	Scattered Density (ac.)	Total Infested Area (ac.)
Mullein	147	183	627	500	1357
Diffuse knapweed	381	525	674	377	1957
Musk thistle	9	84	430	346	869

Source: 2001 Annual Vegetation Report for the Rocky Flats Environmental Technology Site (K-H 2002c)

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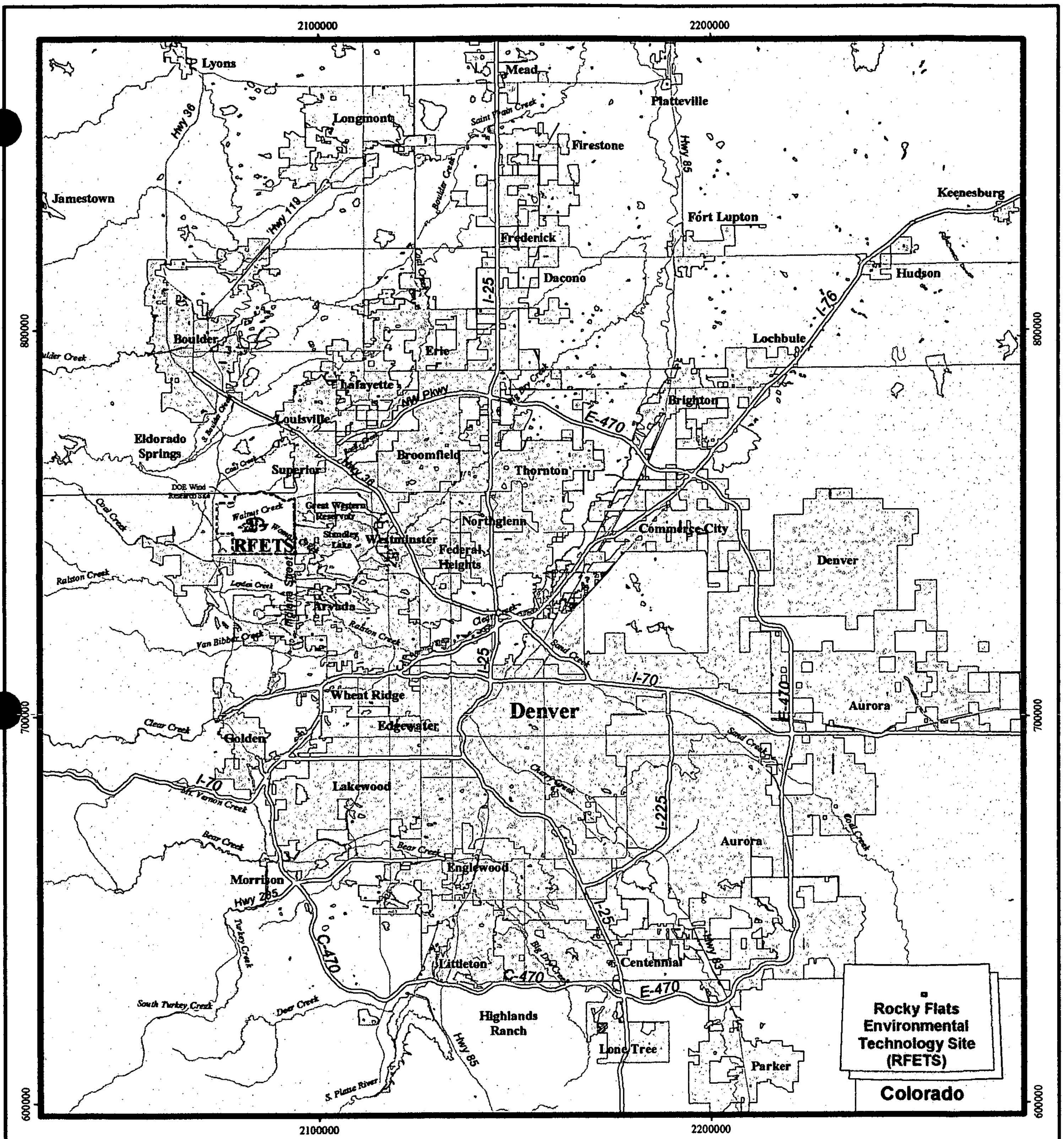
Table 14. Grassland Fires Documented at RFETS Since 1993

Date	Wildfire or Controlled Burn	Location	Estimated Burn Area (acres)
1993	Wildfire	South BZ, approximately 0.2 mile southeast of Pond C-1	0.14
1994	Wildfire	North BZ, adjacent to Highway 128, directly north of IA	70
1996 (Labor Day)	Wildfire	Southwest BZ, contained by BZ roads	104
2000 (April 6)	Controlled burn	Southwest BZ, contained by BZ roads (partial overlap with 1996 Labor Day fire area)	48
2000 (July 10)	Wildfire	Southeast BZ, approximately 0.3 mile south of east access gate on Indiana Street	8
2000 (September 10)	Wildfire	Northwest BZ, north of Pond A-4 and approximately 0.2 mile south of Highway 128	0.52
2002 (February 24)	Wildfire	Northeast BZ, adjacent to Highway 128, north of Landfill Pond	26
2002 (February 24)	Wildfire	Northeast BZ, between Highway 128 and Lindsay Pond 1	1

Source: Rocky Flats National Wildlife Refuge Final CCP and EIS (FWS 2004a)



U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Date: December 23, 2004

URS

Prepared for:

KAISER-HILL

Figure 1
Location of
Rocky Flats Environmental
Technology Site (RFETS)

35000 0 35000
Scale in Feet

DRAFT

N

Scale = 1 : 420,000
1 inch represents 35,000 feet

Transverse Mercator Coordinate System
GCS North American 1983
Datum: D_North_American_1983

94

no roads
functional channel

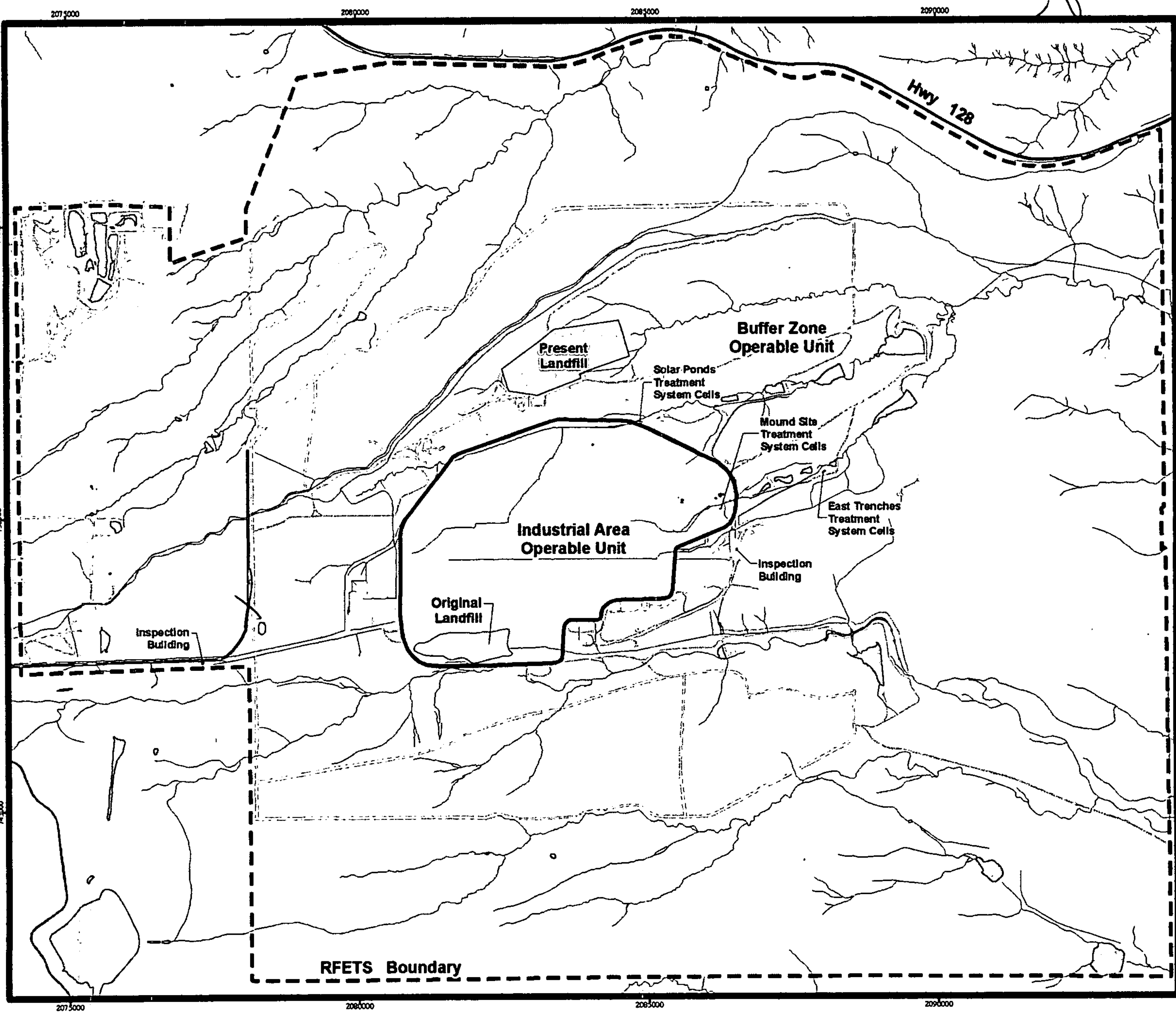


Figure 2

RFETS Surface Features After Active Remediation

Legend

- Original Landfill cover
- Present Landfill cover

Standard Map Features

- Lake or pond
- Stream, ditch, or other drainage feature
- Dirt road
- Gravel road
- RFETS boundary

DRAFT

N
W E
S

500 0 500 1000 1500 2000 2500
Scale in Feet
Scale = 1 : 30,000
1 inch represents 2,500 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Date: February 15, 2005

URS

Prepared for:

KAISER-HILL

Easement Number	Easement Description
1	30' Gas Easement
2	50' x 150' Gas Easement
3	33' Gas Easement
4	20' Gas Easement
5	50' Gas Easement
6	20' Gas Easement
7	49.5' Gas Easement
8	20' Gas Easement
9	20' Gas Easement
10	No Easement available for gasline in this area.
11	150' 230 Kv Electrical Easement
12	150' 230 Kv Electrical Easement
13	150' 230 Kv Electrical Easement
14	150' 230 Kv Electrical Easement
15	150' 230 Kv Electrical Easement
16	150' 230 Kv Electrical Easement
17	75' 115 Kv Electrical Easement
18	No Easement description
19	100' 230 Kv "Simms"
20	License Agreement for Right-of-Way for Electrical Line
21	License Agreement for Right-of-Way for Electrical Line
22	Access Easement
23	Telecom to Building 060
24	License Agreement to cross Boulder Ditch
25	10' Wide Telephone Easement
26	20' Wide Telephone Easement
27	Easement for Right-of-Way
28	Telephone Line Fiber Optics Service to RFETS
29	Electrical Powerline within DOE RFETS property No Easement.
30	DOE owned Electrical Power line
31	Tract 22E
32	Parcel #1, Railroad Spur
33	Parcel #2, Railroad Spur
34	Parcel #3, Railroad Spur
35	Parcel #4, Railroad Spur
36	blank
37	Tract 26L, License/Agreement
38	Tract 25E
39	Tract 23E

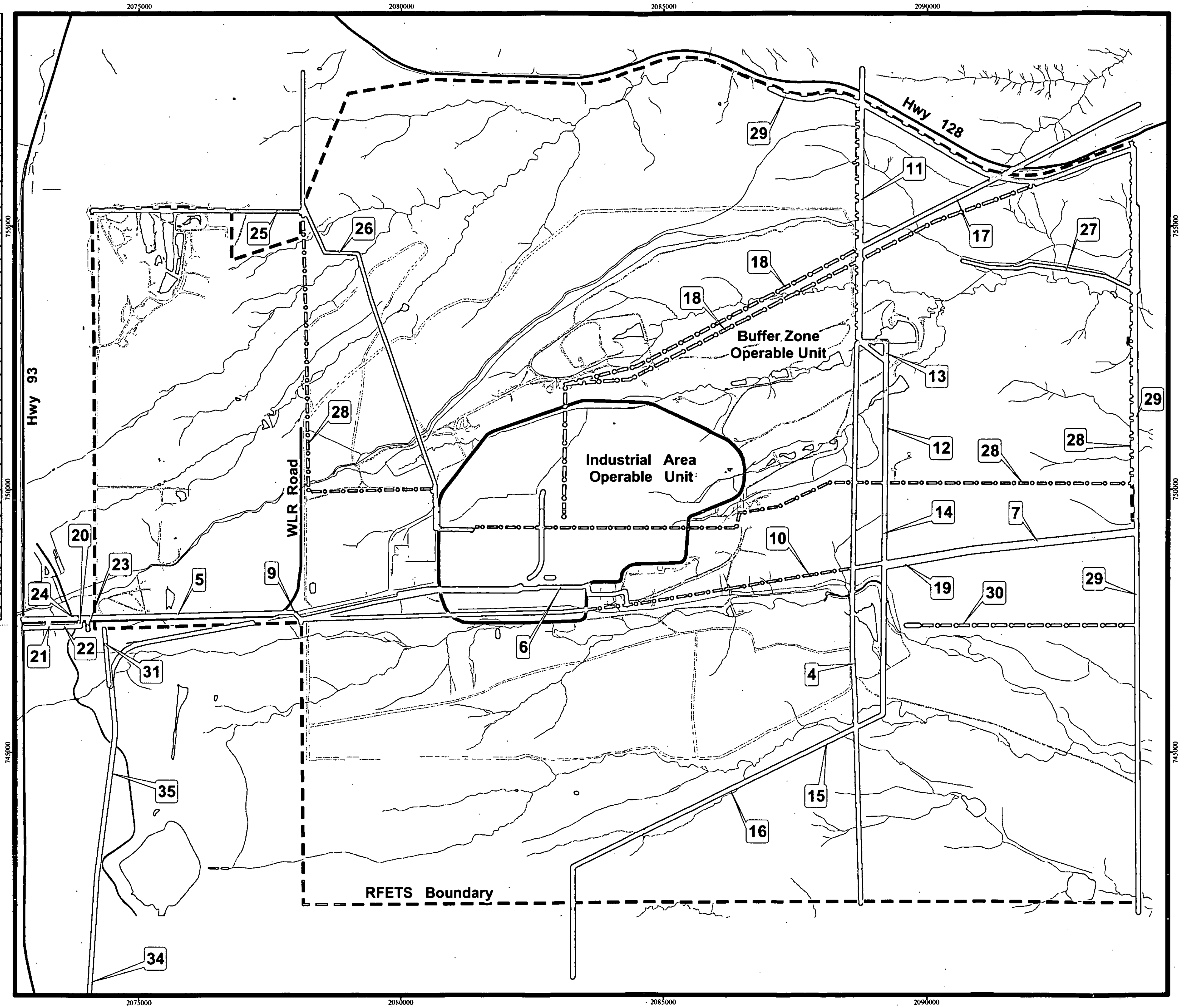


Figure 3

Easement Location Map

Legend

- Raw water easement
- Railroad right-of-way
- Natural gas easement
- Natural gas (no easement documents)
- Telephone easement
- Telephone (no easement documents)
- Electrical transmission easement
- Electrical (no easement documents)

Standard Map Features

- Lake or pond
- Stream, ditch, or other drainage feature
- Dirt road
- Gravel road
- RFETS boundary

DRAFT

N W E S

500 0 500 1000 1500 2000 2500
Scale in Feet

Scale = 1 : 24,000
1 inch represents 2,000 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Date: February 16, 2005

URS

Prepared for:

KAISER-HILL

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96

Figure 4. Subsurface Features After Active Remediation

Figure to be determined after sub-surface features that remain are confirmed/verified

Include features such as groundwater treatment systems, utilities, building basements.

97

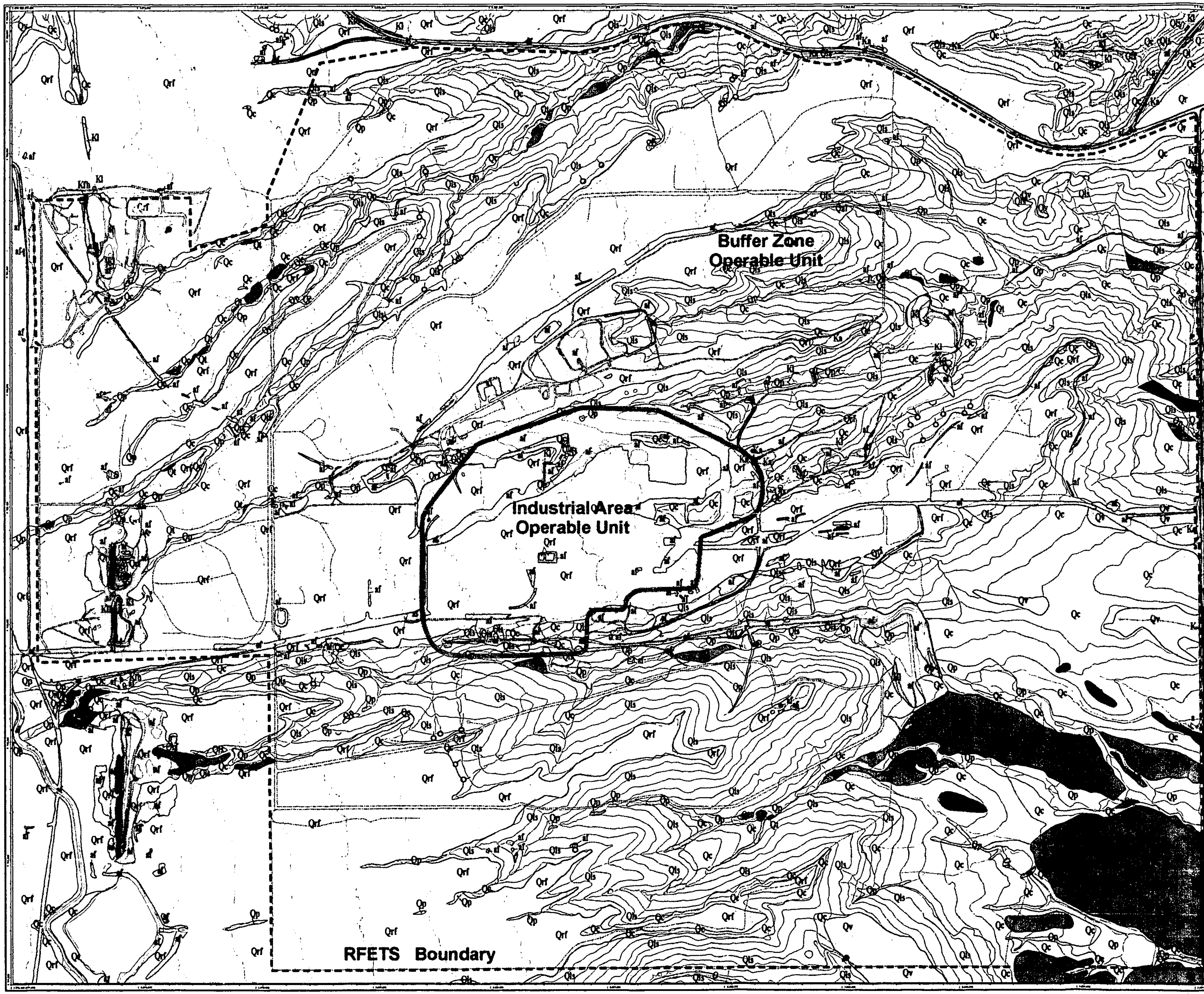

Figure 7

Geologic Units at Rocky Flats Environmental Technology Site

Produced in cooperation with the U.S. Geological Survey

Geologic Map Units

- af - Artificial fill
- Qp - Post-Piney Creek and Piney Creek Alluvium
- Qt - Terrace Alluvium
- Qc - Colluvium
- Qls - Landslide deposits
- Qs - Slocum Alluvium
- Qv - Verdos Alluvium
- Qrf - Rocky Flats Alluvium
- Ka - Arapahoe Formation
- Kl - Laramie Formation
- Kfh - Fox Hills Sandstone

Symbols

- Shallow closed depression
- Scarp of young landslide
- Areas of vegetation at and near springs
- Boundary of gravel and clay pit
- Spring
- Strike and dip of beds
- Clast identification site
- Capitol Mine (abandoned)
- Geologic Units boundaries

Standard Map Features

- Lakes and ponds
- Streams, ditches, or other drainage features
- Topographic Contour (20-Foot)
- Rocky Flats Environmental Technology Site boundary
- Paved roads
- Dirt roads
- Industrial Area Operable Unit Boundary

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

Location of buildings, roads, and fences by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology by Water Resources Division USGS - (date and author unknown)
Geologic Mapping : Shroba, R.R., and Carrara, P.E. Preliminary Surficial Geologic Map of the Rocky Flats Plant and Vicinity, Jefferson and Boulder Counties, Colorado: U.S. Geological Survey Open-File Report 94-162, Scale 1:6000
Site source of topo base; see OFR 94-162 (on map).

Scale = 1 : 21330
1 inch represents approximately 1778 feet
250 0 500 1000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

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KAISER-HILL

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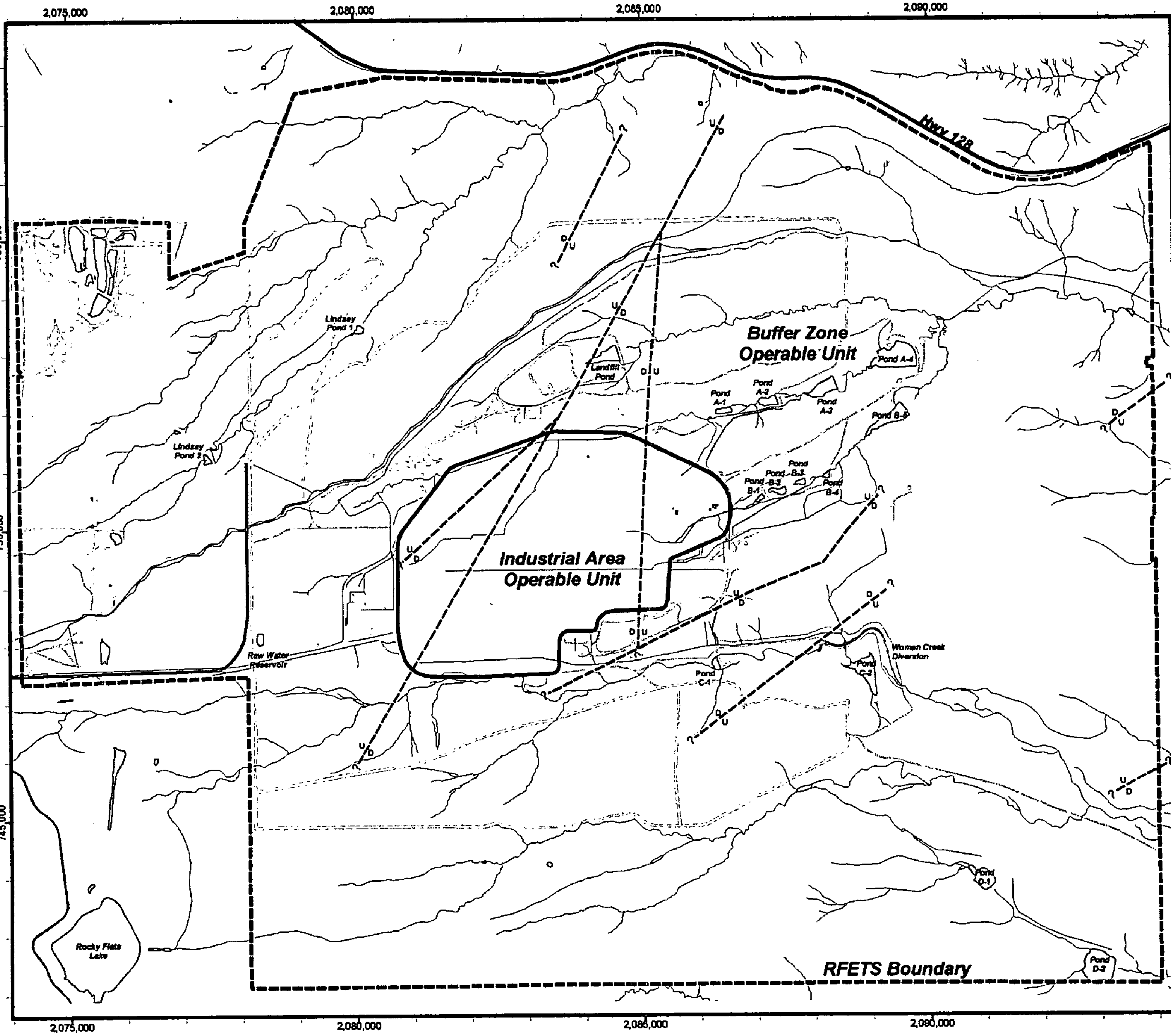
100

101

Figure 8

Inferred Fault Locations



Legend

- Inferred geologic fault
- D Downthrown side of fault
- U Upthrown side of fault
- Lake or pond
- Stream, ditch, or other drainage feature
- Dirt road
- Gravel road
- RFETS site boundary

Source:
Adapted from Plate 7-1, Geologic Characterization Report (EG&G, 1995)

DRAFT

Scale = 1 : 30,000
1 inch represents 2,500 feet

500 0 500 1,000 1,500 2,000 2,500

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: URS

Prepared for: KAISER-HILL

January 24, 2005

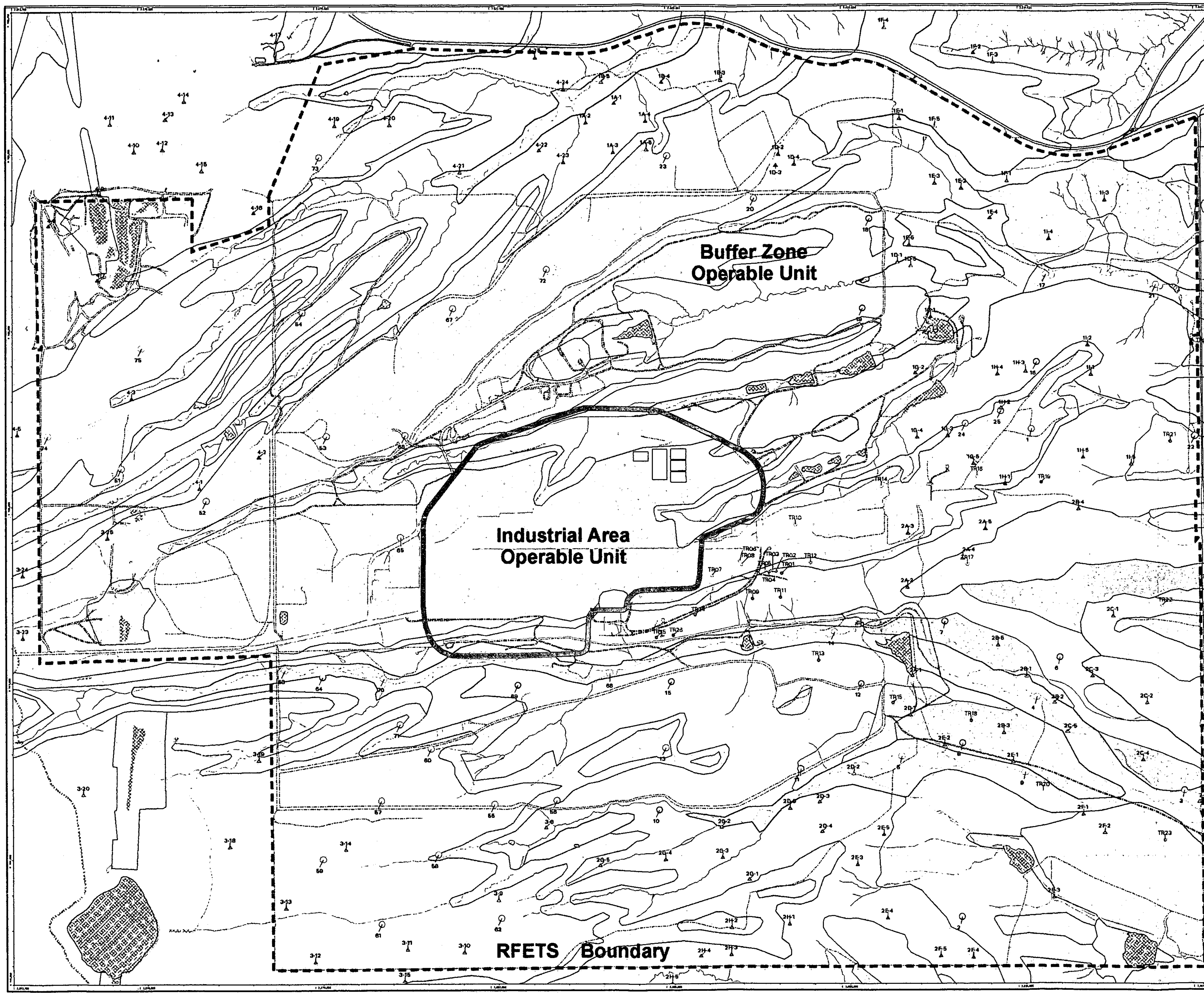


Figure 9
Rocky Flats Soils Map with Hydraulic Conductivity Measurement and Soil Sampling Locations

EXPLANATION

Sampling Features
- Tension infiltrometer sampling location
- Soil Pit Location
- CDPHE Samples

Soils
- Denver clay loam, 2 - 5%
- Denver clay loam, 5 - 9%
- Denver-Kutch clay loam, 5 - 9%
- Denver-Kutch clay loam, 9 - 15%
- Denver-Kutch-Midway clay loam, 9 - 25%
- Englewood clay loam, 0 - 2%
- Englewood clay loam, 2 - 5%
- Flatirons cobbly sandy loam, 0 - 3%
- Flatirons stoney sandy loam, 0 - 5%
- Haverson loam, 0 - 3%
- Leyden-Primen-Standley cobbly clay loams, 15 - 50%
- McClave clay loam, 0 - 3%
- Midway clay loam, 9 - 30%
- Nederland very cobbly sandy loam, 15 - 50%
- Nunn clay loam, 0 - 2%
- Nunn clay loam, 2 - 5%
- Pits, gravel
- Rock outcrop, Sedimentary
- Standley-Nunn gravelly clay loam, 0 - 5%
- Valmont clay loam, 0 - 3%
- Valmont-Nederland very cobbly sandy loam, 0 - 3%
- Willowman-Leyden cobbly loam, 9 - 30%
- Yoder Fariant-Midway complex, 15 - 60%

Standard Map Features
- Lakes and ponds
- Streams, ditches, or other drainage features
- Rocky Flats Environmental Technology Site boundary
- Paved roads
- Dirt roads
- Industrial Area Operable Unit Boundary

DATA SOURCE BASE FEATURES:
Soils data from the US Soil Conservation Service.
Uncertified Golden Area Soil Survey - 1980.
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs. 1/95

Scale = 1 : 20240
1 inch represents approximately 1687 feet
250 0 500 1000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by:
CH2MHILL

Prepared for:
KAISER-HILL COMPANY

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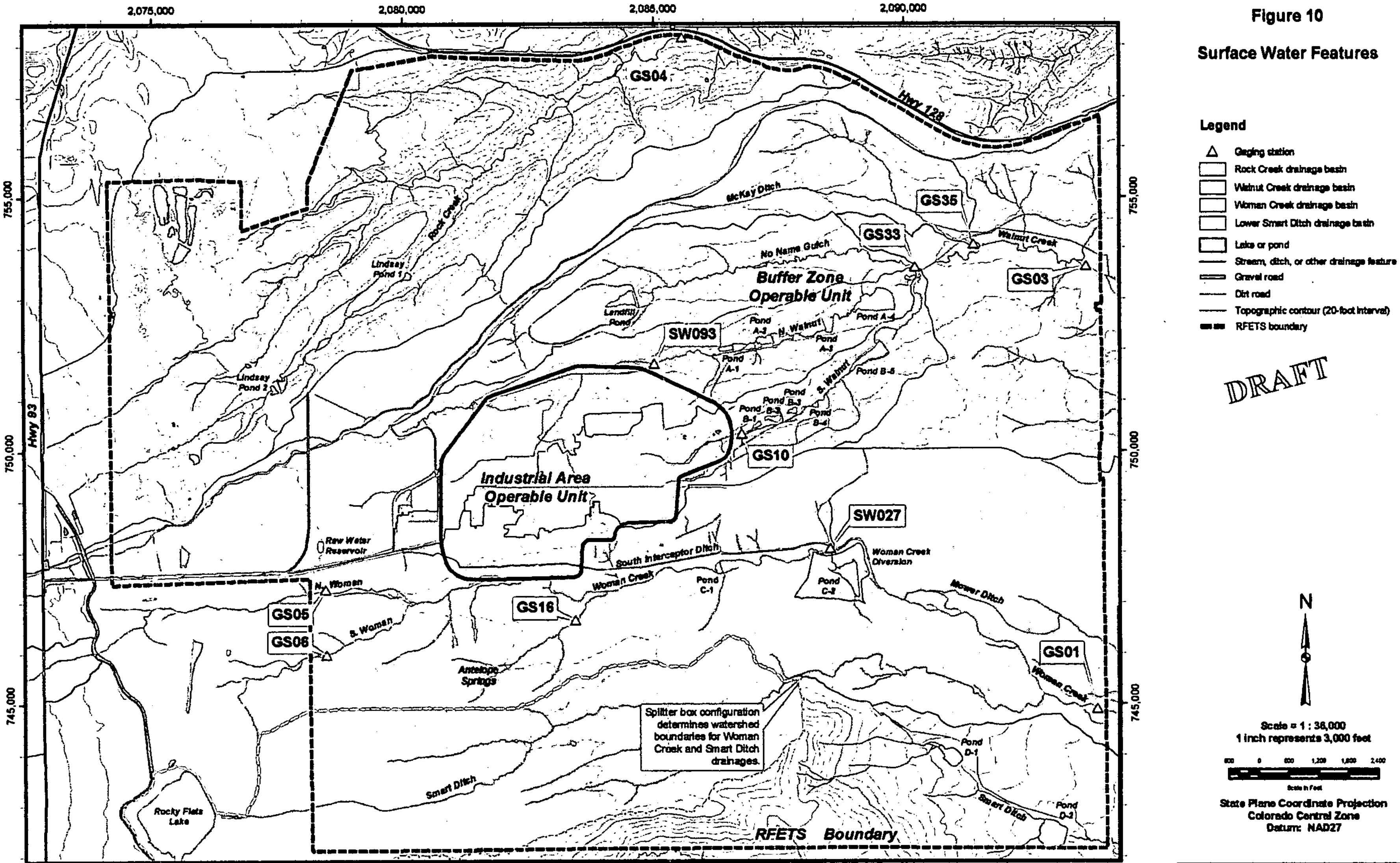
102

Figure 10

Surface Water Features



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103

104

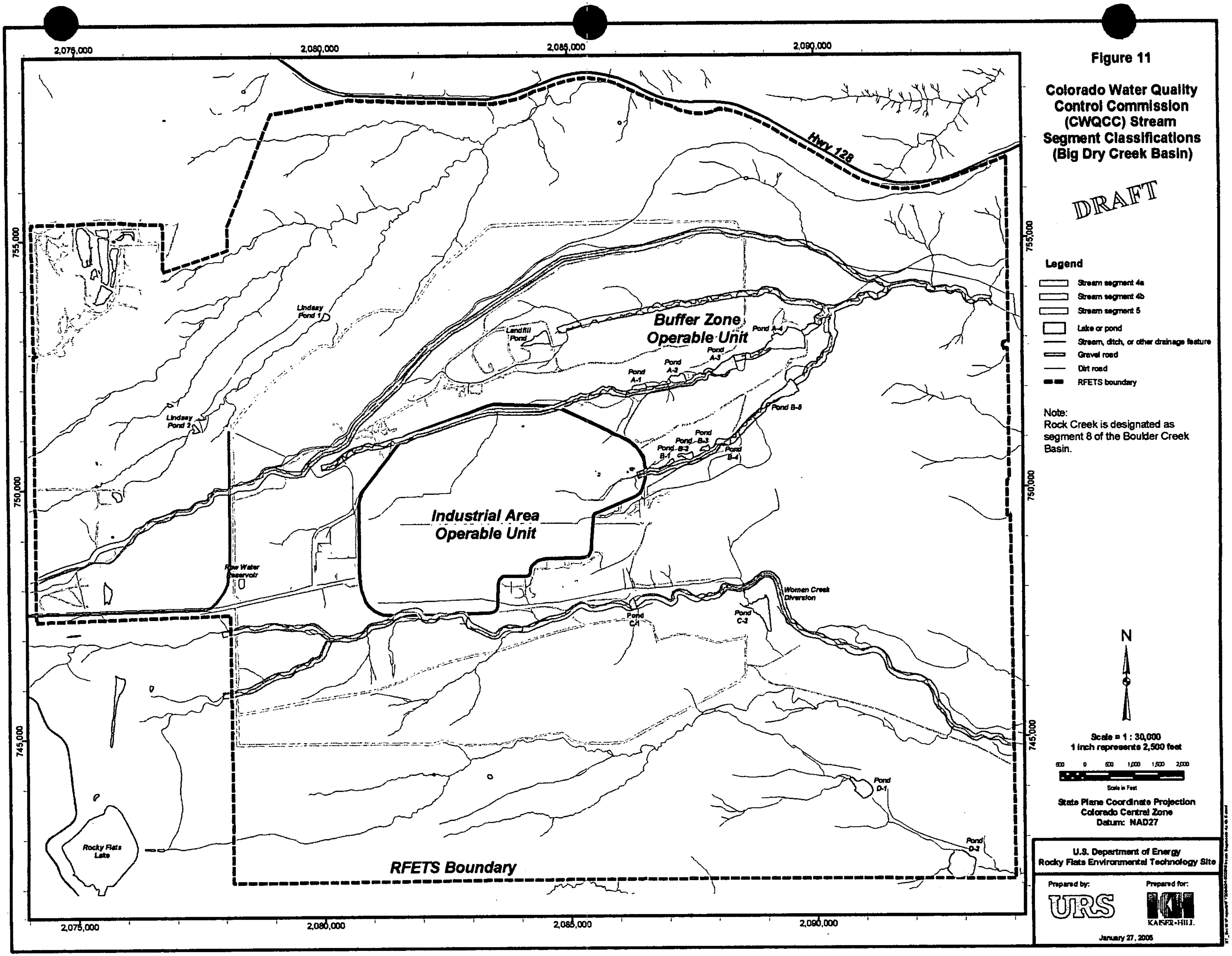
Figure 11
Colorado Water Quality Control Commission (CWQCC) Stream Segment Classifications (Big Dry Creek Basin)
DRAFT
Legend
Stream segment 4a
Stream segment 4b
Stream segment 5
Lake or pond
Stream, ditch, or other drainage feature
Gravel road
Dirt road
RFETS boundary
Note:
Rock Creek is designated as segment 8 of the Boulder Creek Basin.
N
Scale = 1 : 30,000
1 inch represents 2,500 feet
Scale in Feet
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27
U.S. Department of Energy
Rocky Flats Environmental Technology Site
Prepared by:
URS
Prepared for:
KAISER-HILL
January 27, 2005
2,075,000
2,080,000
2,085,000
2,090,000
755,000
750,000
745,000
Hwy 128
Buffer Zone Operable Unit
Industrial Area Operable Unit
RFETS Boundary
Landfill Pond
Lindsay Pond 1
Lindsay Pond 2
Pond A-1
Pond A-2
Pond A-3
Pond A-4
Pond B-1
Pond B-2
Pond B-3
Pond B-4
Pond B-5
Raw Water Reservoir
Women Creek Diversion
Pond C-1
Pond C-2
Pond D-1
Pond D-2
Rocky Flats Lake

105

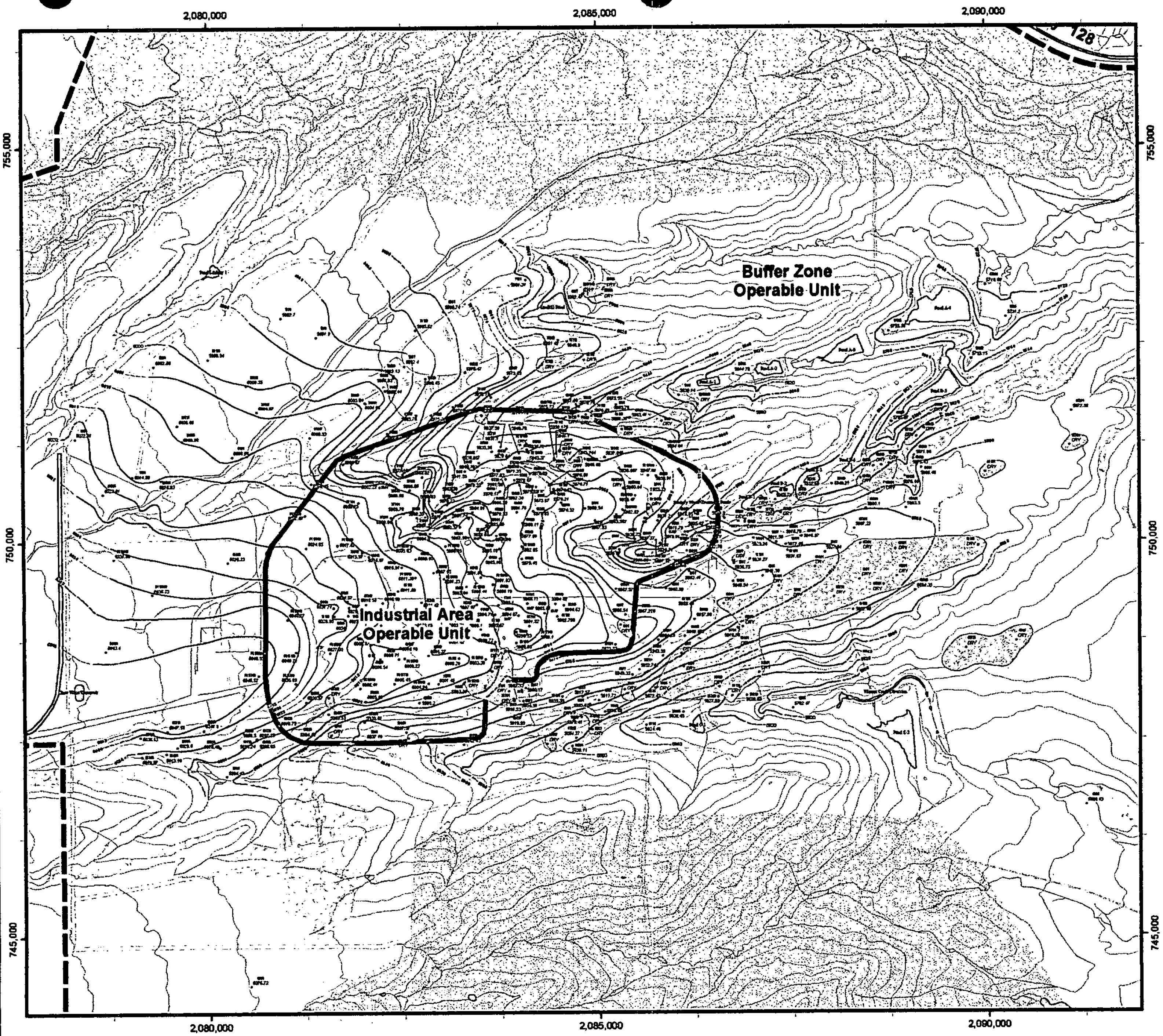

Figure 12

Potentiometric Surface of Permeable Units of the UHSU Second Quarter (2003)

Legend

- Well with water level
- Dry well
- Potentiometric contour (20-foot interval)
- Inferred potentiometric contour
- Potentiometric contour (5-foot interval)
- Inferred potentiometric contour
- Approximate current extent of unsaturated alluvium
- Seep
- Area without groundwater elevation data
- Lake or pond
- Stream, ditch, or other drainage feature
- Gravel road
- Dirt road
- Topographic contour (20-foot interval)
- RFETS boundary

Source:
Potentiometric contours were taken from Plate 2, Sitewide Potentiometric Surface, Second Quarter 2003, 2003 RFCA Annual Report, URS (2004)

DRAFT

N

Scale = 1 : 21,600
1 inch represents 1,800 feet

600 0 600 1,200

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: URS

Prepared for: KAISER-HILL

January 24, 2005

106

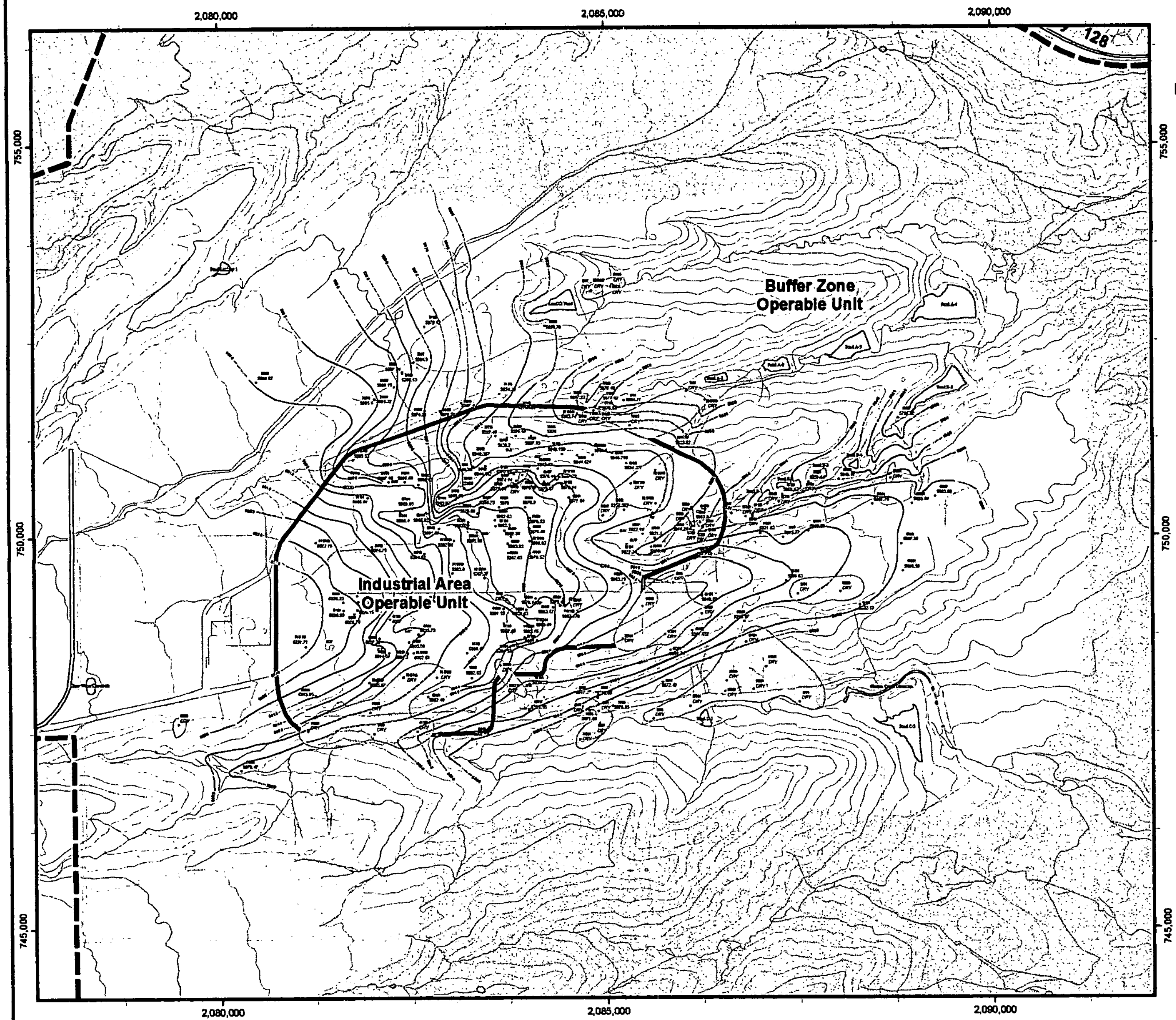

Figure 13

Potentiometric Surface of Permeable Units of the UHSU Fourth Quarter (2003)

Legend

- Well with water level
- Dry well
- Potentiometric contour (20-foot interval)
- Inferred potentiometric contour
- Potentiometric contour (5-foot interval)
- Inferred potentiometric contour
- Approximate current extent of unsaturated alluvium
- Seep
- Area without groundwater elevation data
- Lake or pond
- Stream, ditch, or other drainage feature
- Gravel road
- Dirt road
- Topographic contour (20-foot interval)
- RFETS boundary

Source:
Potentiometric contours were taken from Plate 3, Sitewide Potentiometric Surface, Fourth Quarter 2003, 2003 RFCA Annual Report, URS (2004)

N

Scale = 1 : 21,600
1 inch represents 1,800 feet

600 0 600 1,200

Scale in Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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Rocky Flats Environmental Technology Site

Prepared by: URS

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January 24, 2005

107

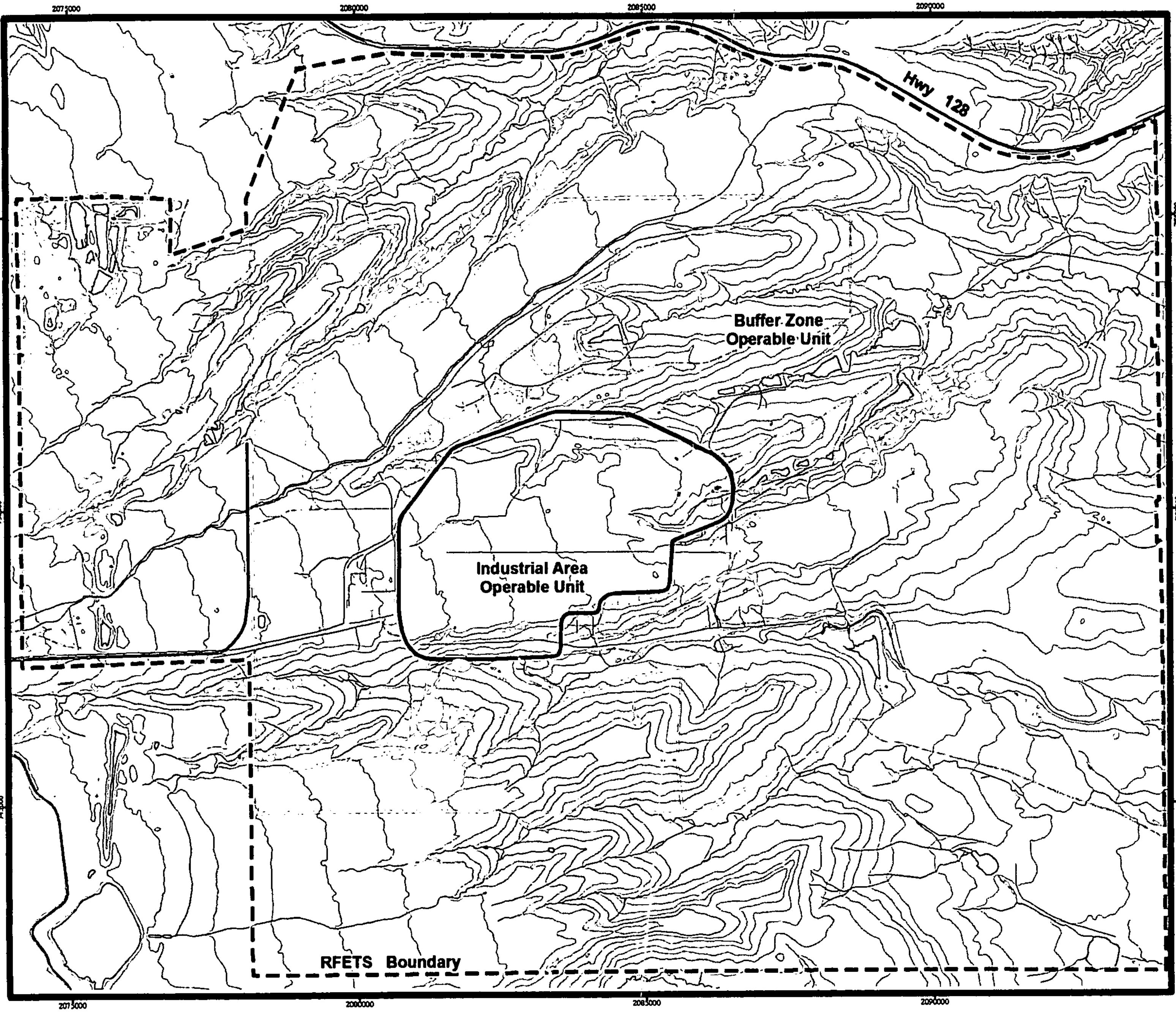


Figure 14

Seep Areas

Standard Map Features

- Seep
- Lake or pond
- Stream, ditch, or other drainage feature
- Dirt road
- Gravel road
- Topographic contour (20-foot)
- RFETS boundary

Data Source:
Seep locations from EG&G, 1995, Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site.

DRAFT

N
W E
S

500 0 500 1000 1500 2000
Scale in Feet

Scale = 1 : 30,000
1 inch represents 2,500 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

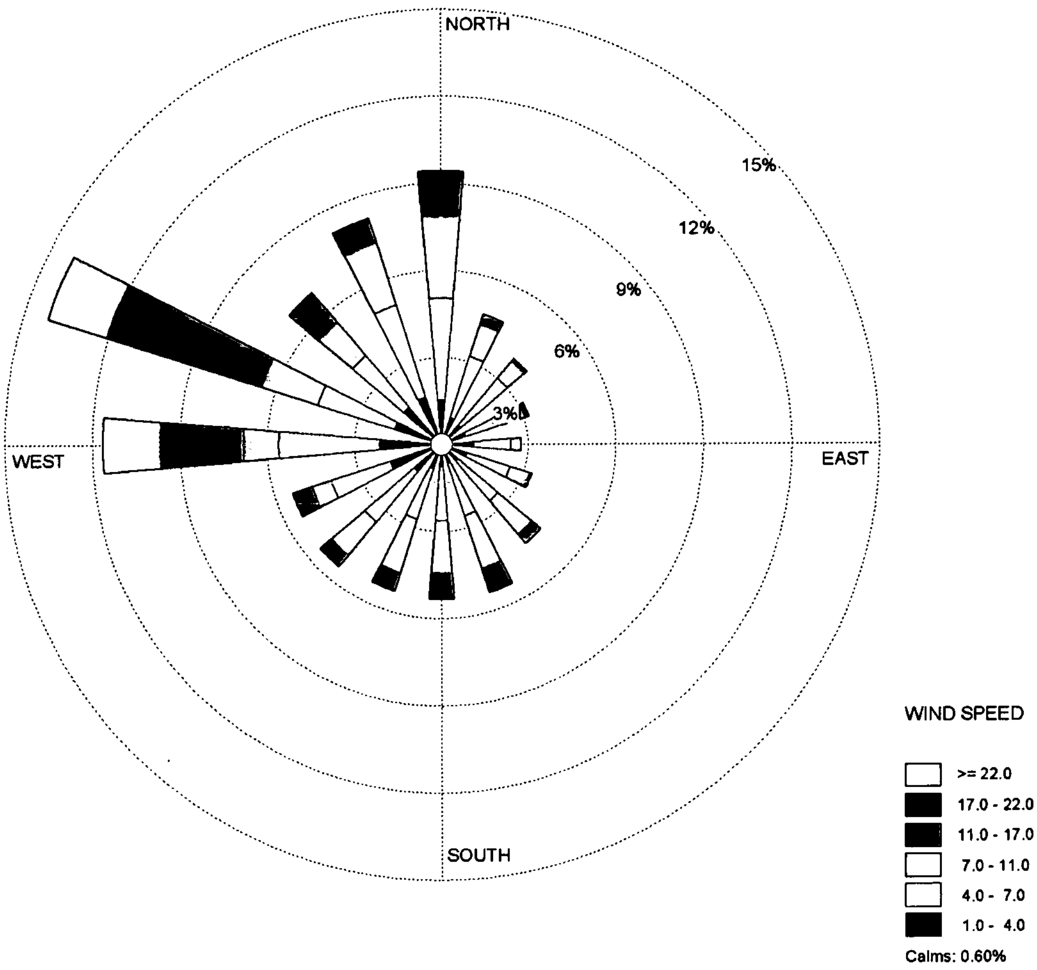
Prepared by: Date: February 15, 2005

URS

Prepared for:

KAISER•HILL

Figure 15. Wind Speed and Direction - 2004



Units = miles per hour

Frequency distribution based on windspeed data collected at 15-minute intervals

108

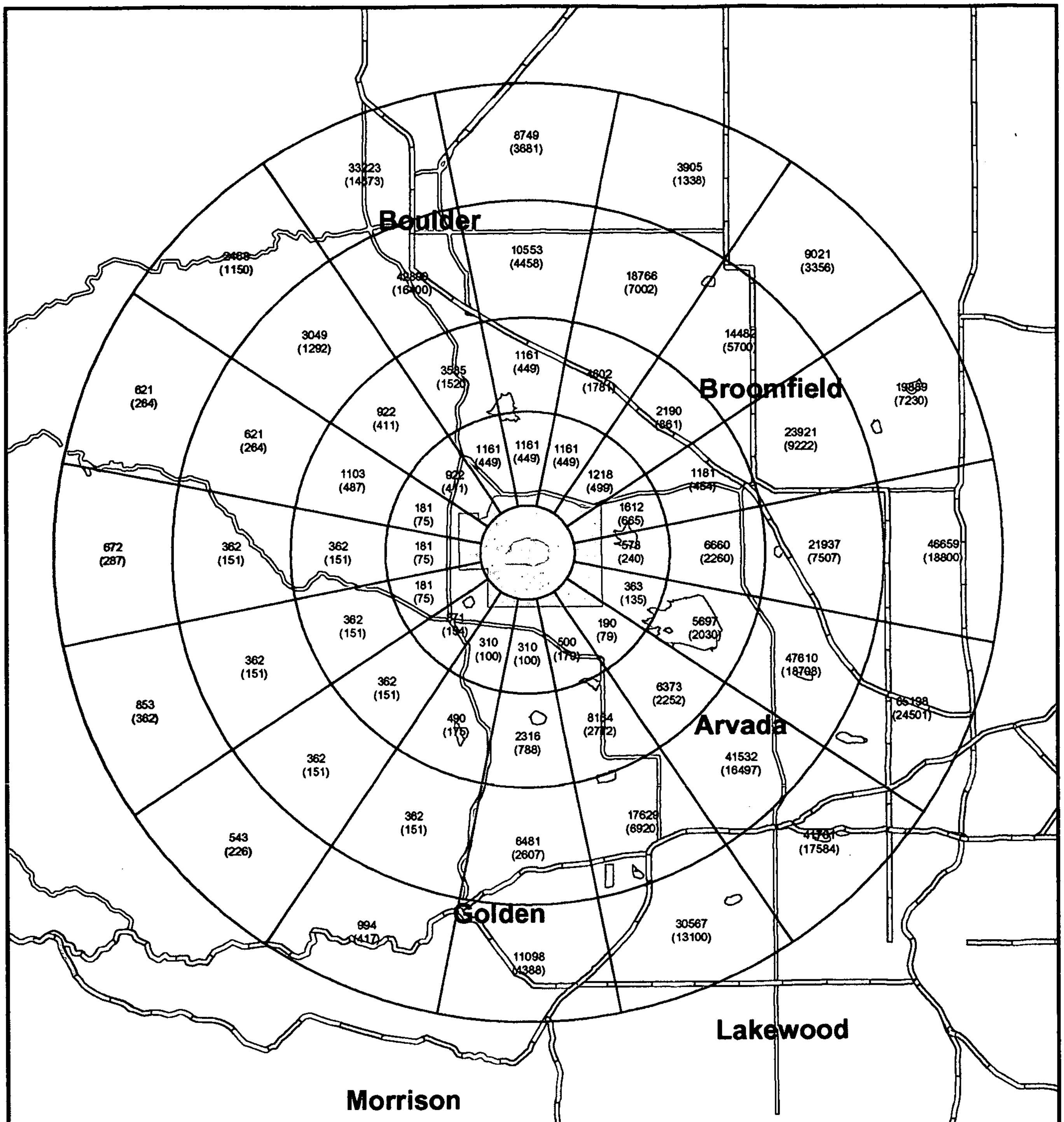


Figure 16 Population Distribution, 2004

The center of the pie chart is the location of Rocky Flats Environmental Technology Site. The numbers in parentheses represent the number of households.

\\GisSrv\GIS\Projects\fy2004\04-0569\Population-Households2004.mxd

109

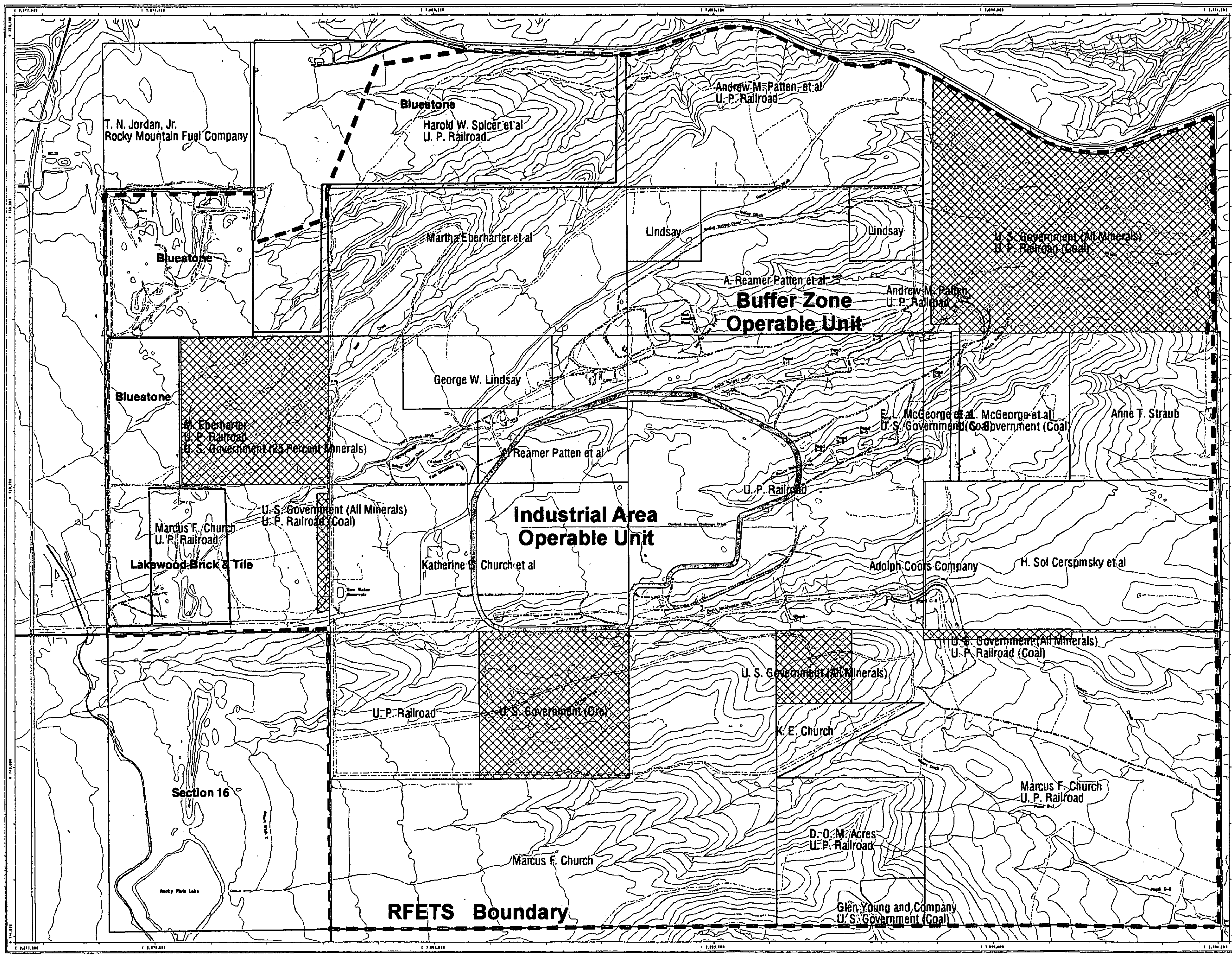


Figure 17
Mineral Rights at Rocky Flats Environmental Technology Site

EXPLANATION

- Existing Mining Permit
- Mineral Right Boundary
- Government
- Bluestone
- Lakewood Brick & Tile
- Section 16

Standard Map Features

- Lakes and ponds
- Streams, ditches, or other drainage features
- Topographic Contour (20-Foot)
- Rocky Flats Environmental Technology Site boundary
- Paved roads
- Dirt roads
- Industrial Area Operable Unit Boundary

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution. DEM post-processing performed by MK, Winter 1997.
DATA SOURCE - Mineral Rights Lease Boundaries - Approved by RFCSS Facility Planning Dept., POC Norm Sprofes, 303-866-2303.

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Scale = 1 : 21330
1 inch represents approximately 1778 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: CH2MHILL

Prepared for: KAISER-HILL COMPANY

January 26, 2005

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110

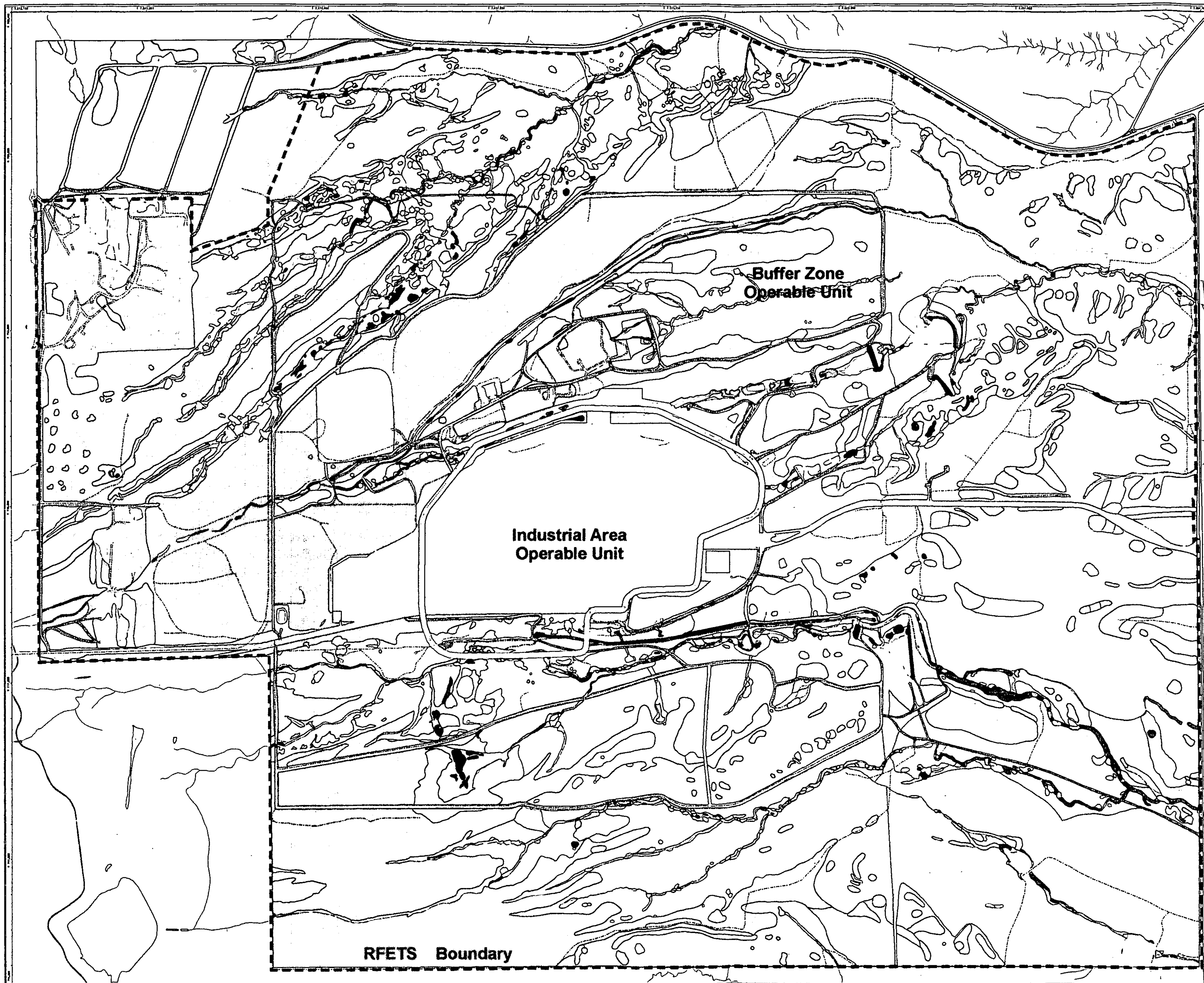

Figure 18

Rocky Flats Vegetation Map

LEGEND

- Riparian Woodland
- Leadplant Riparian Shrubland
- Wet Meadow/Marsh Ecotone
- Short Upland Shrubland
- Willow Riparian Shrubland
- Annual Grass/Forb Community
- Xeric Tallgrass Prairie
- Ponderosa Woodland
- Reclaimed Mixed Grassland
- Mesic Mixed Grassland
- Savannah Shrubland
- Tall Upland Shrubland
- Short Marsh
- Xeric Needle and Thread Grass Prairie
- Short Grassland
- Disturbed and Developed Areas
- Open Water
- Riprap, Rock, and Gravel Piles
- Mudflats
- Tree Plantings
- Tall Marsh
- Revegetated Grassland

Standard Map Features

- Lakes and ponds
- Streams, ditches, or other drainage features
- Rocky Flats Environmental Technology Site boundary
- Paved roads
- Dirt roads
- Industrial Area Operable Unit Boundary

DATA SOURCE BASE FEATURES:

Vegetation map data provided by PTI Environmental Services Ecology Group.

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

NOTES:

This map does not show all Federally designated wetlands. See the 1995 Site wetlands map prepared by the U.S. Army Corps of Engineers for delineated wetland features.

Scale = 1 : 20240
1 inch represents approximately 1687 feet

250 0 500 1000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy

Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by:

CH2MHILL

Prepared for:

KAISER-HILL

January 18, 2005

NT_Svr w:/projects/actinide_pathway_report/fy2002/misc_maps/veg_site_closure.aml

112

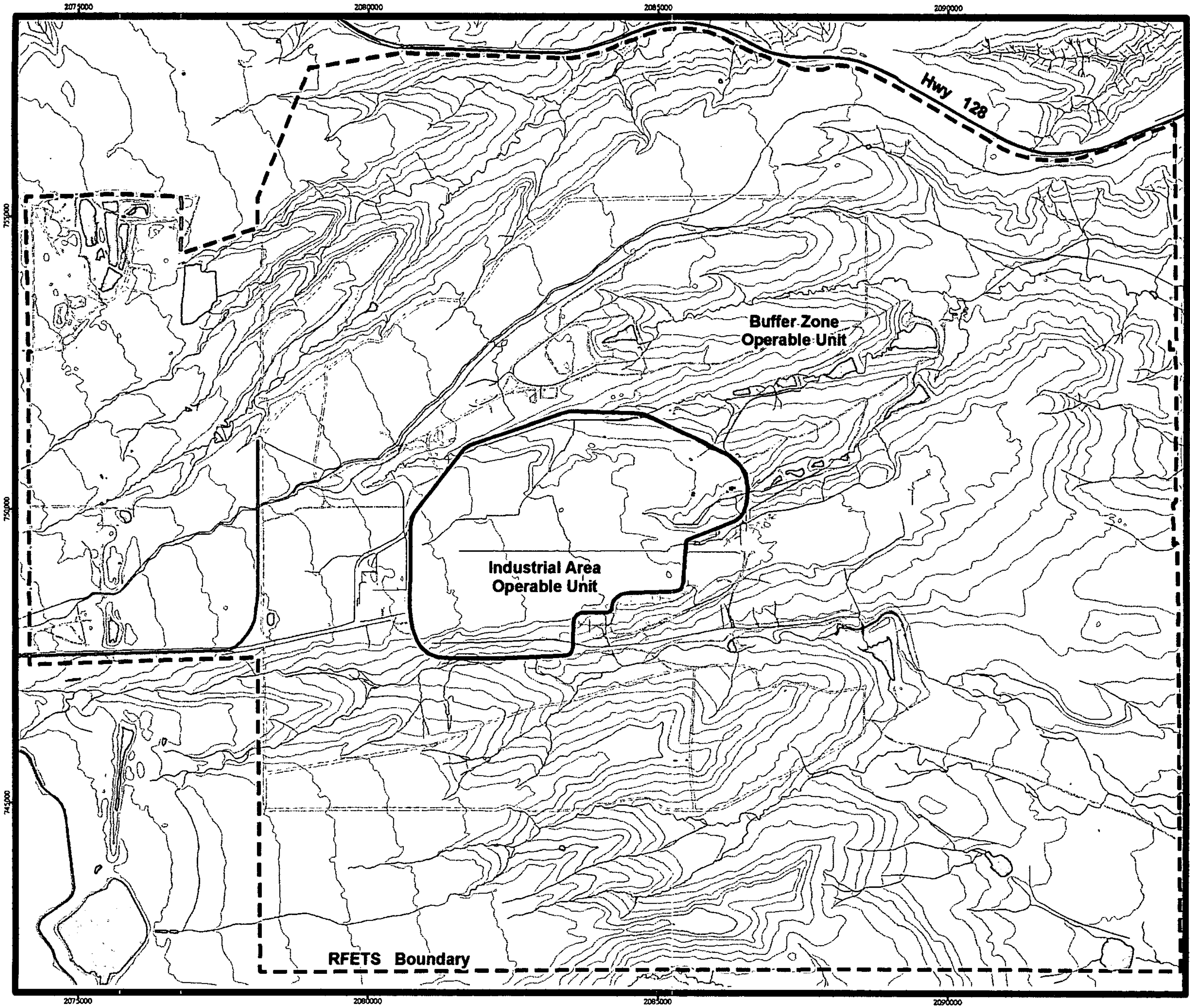

Figure 19

Windblown Sand Deposition Area

Standard Map Features

- Windblown sand deposition area
- Lake or pond
- Stream, ditch, or other drainage feature
- Dirt road
- Gravel road
- Topographic contour (20-foot)
- RFETS boundary

Source:
2001 Annual Vegetation Report for the RFETS, Kaiser-Hill Company, L.L.C. May 2002

DRAFT

N W E S

500 0 500 1000 1500 2000

Scale in Feet

Scale = 1 : 30,000
1 inch represents 2,500 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Date: February 15, 2005

URS

Prepared for:

KAISER-HILL

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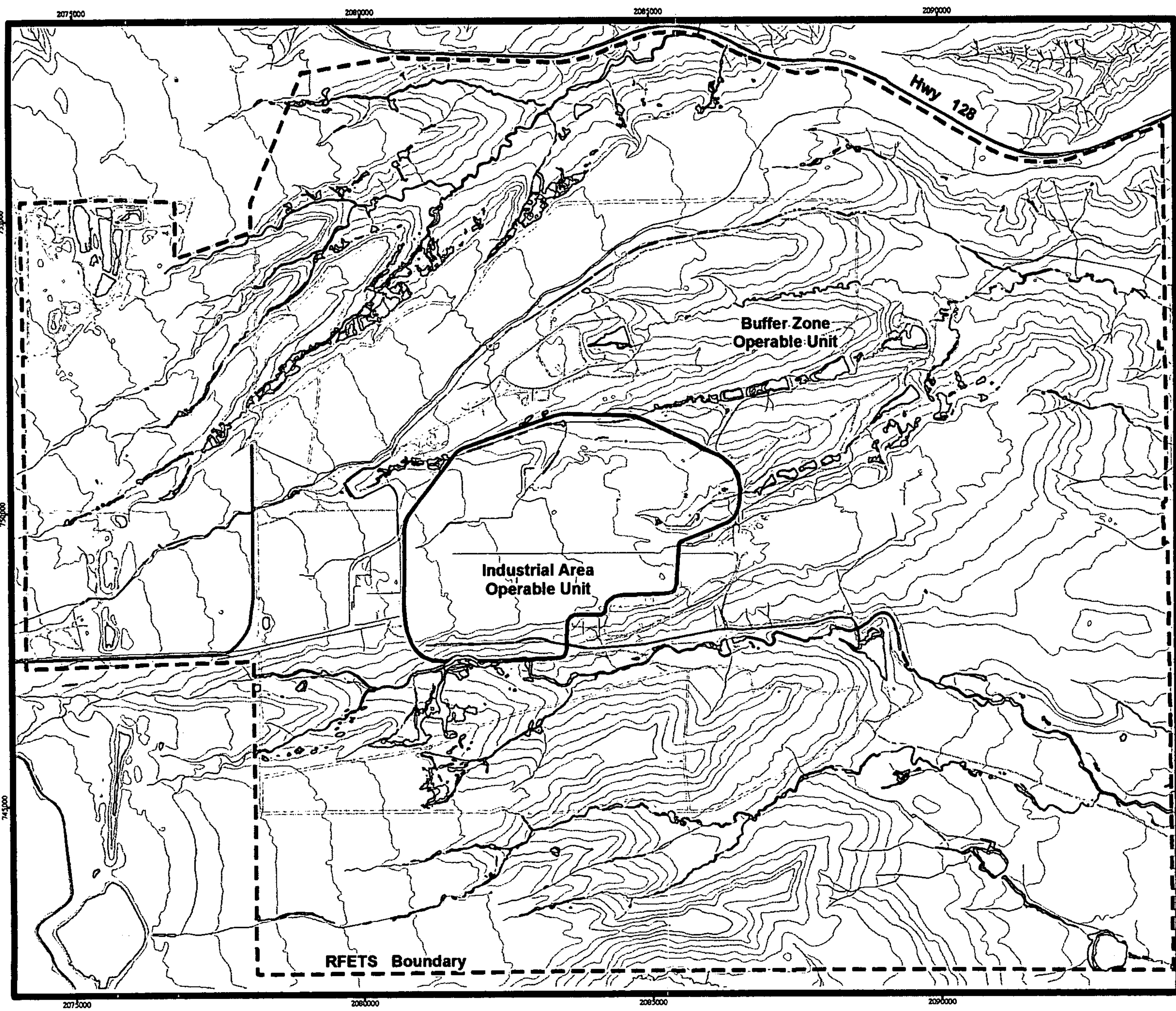
Figure 20

Wetland Location Map



Standard Map Features

- Wetlands location
- Lake or pond
- Stream, ditch, or other drainage feature
- Dirt road
- Gravel road
- Topographic contour (20-foot)
- RFETS boundary

DRAFT

N
W E
S

500 0 500 1000 1500 2000

Scale in Feet

Scale = 1 : 30,000

1 inch represents 2,500 feet

State Plane Coordinate Projection

Colorado Central Zone

Datum: NAD27

U.S. Department of Energy

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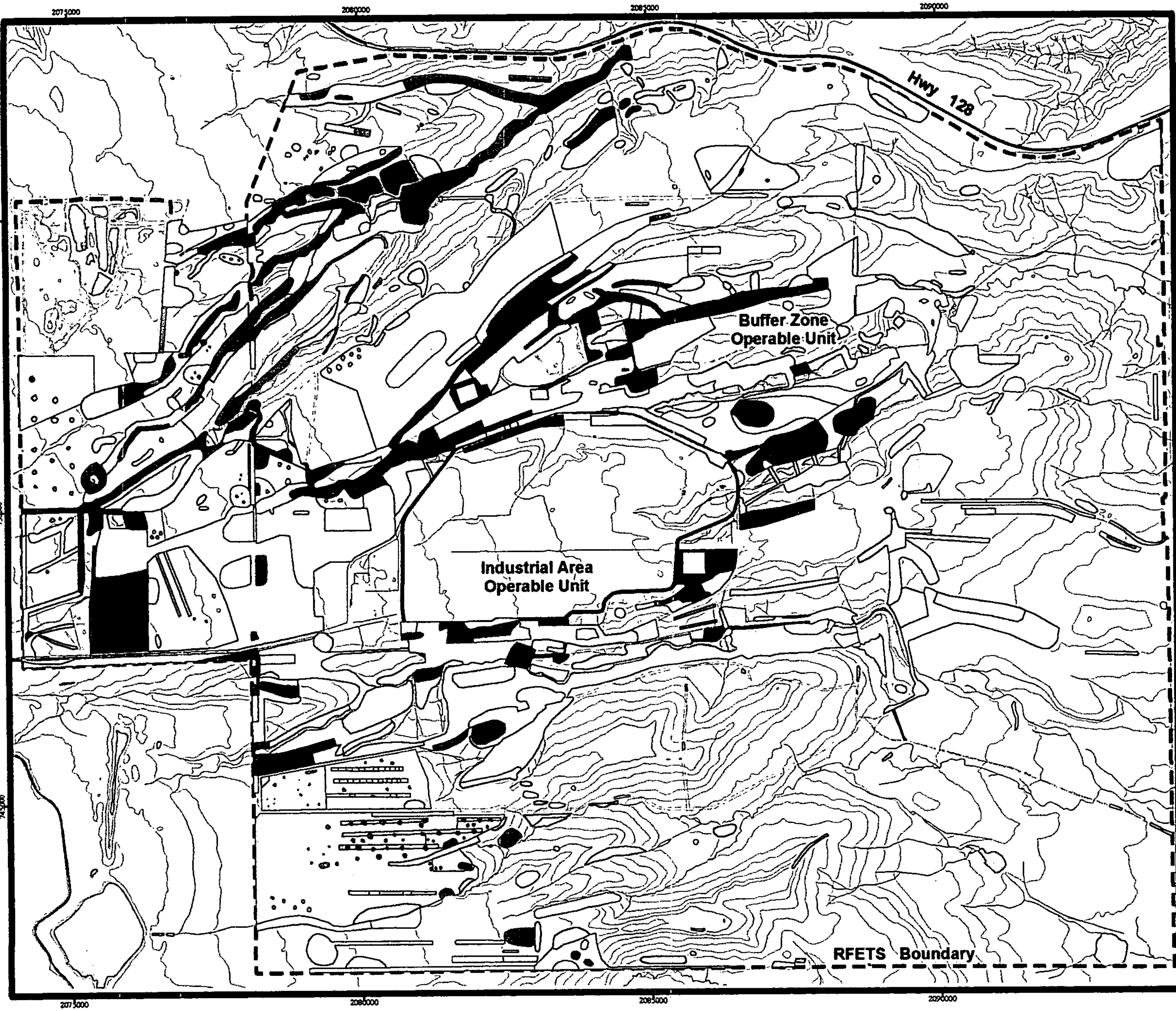

Figure 21
Diffuse Knapweed (Centaurea diffuse) 2001 Distribution

Standard Map Features

- High density area
- Medium density area
- Low density area
- Scattered density area
- Lake or pond
- Stream, ditch, or other drainage feature
- Dirt road
- Gravel road
- Topographic contour (20-foot)
- RFETS boundary

Source:
2001 Annual Vegetation Report for the RFETS, Kaiser-Hill Company, L.L.C. May 2002

DRAFT

N W E S

500 0 500 1000 1500 2000
Scale in Feet

Scale = 1 : 30,000
1 inch represents 2,500 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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Rocky Flats Environmental Technology Site

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Prepared for:

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114

115

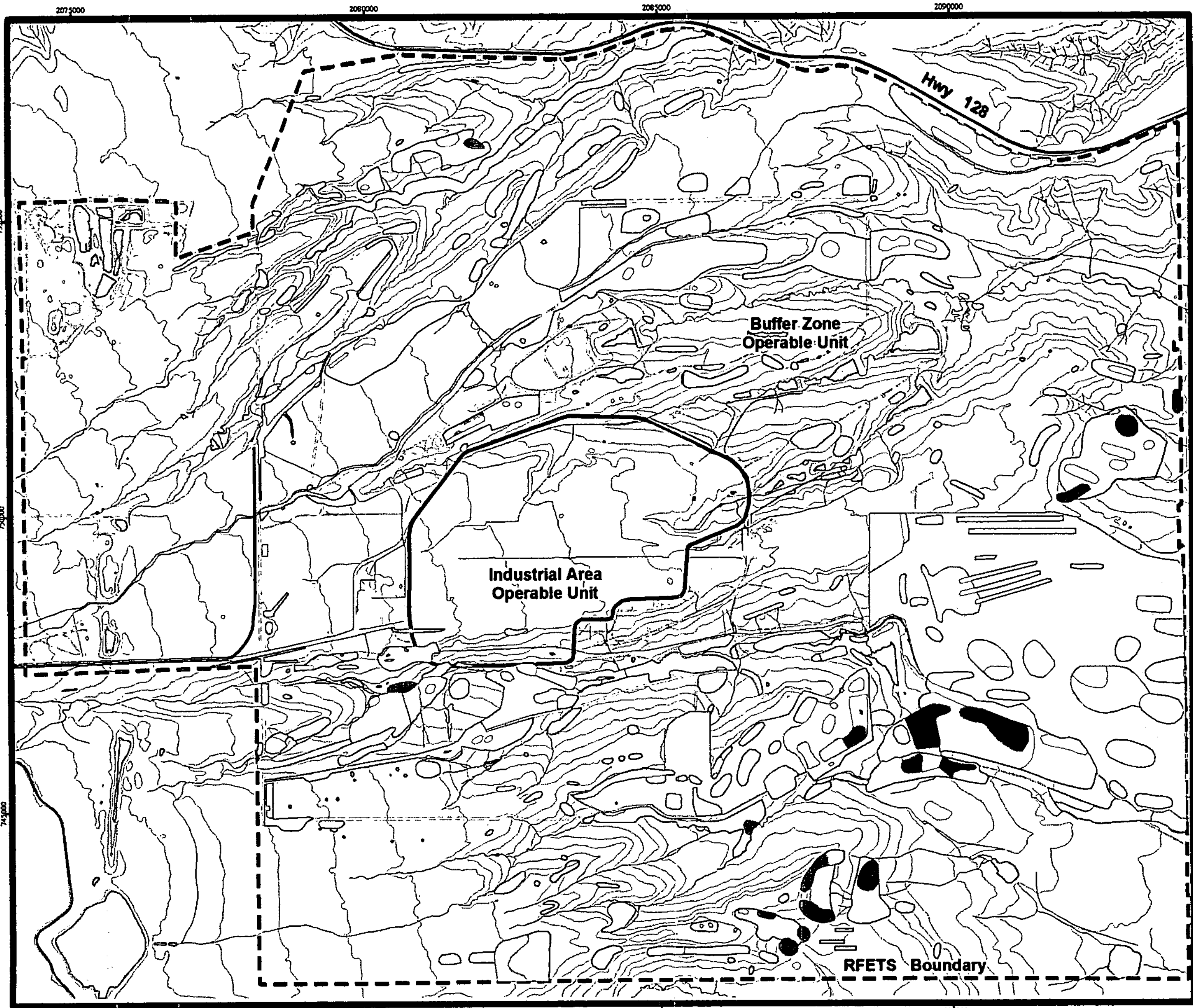

Figure 22
Common Mullein (Verbascum thapsus) 2001 Distribution

Standard Map Features
- High density area
- Medium density area
- Low density area
- Scattered density area
- Lake or pond
- Stream, ditch, or other drainage feature
- Dirt road
- Gravel road
- Topographic contour (20-foot)
- RFETS boundary

Source:
2001 Annual Vegetation Report for the RFETS, Kaiser-Hill Company, L.L.C. May 2002

DRAFT

N
W E
S

500 0 500 1000 1500 2000 2500
Scale in Feet

Scale = 1 : 30,000
1 inch represents 2,500 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

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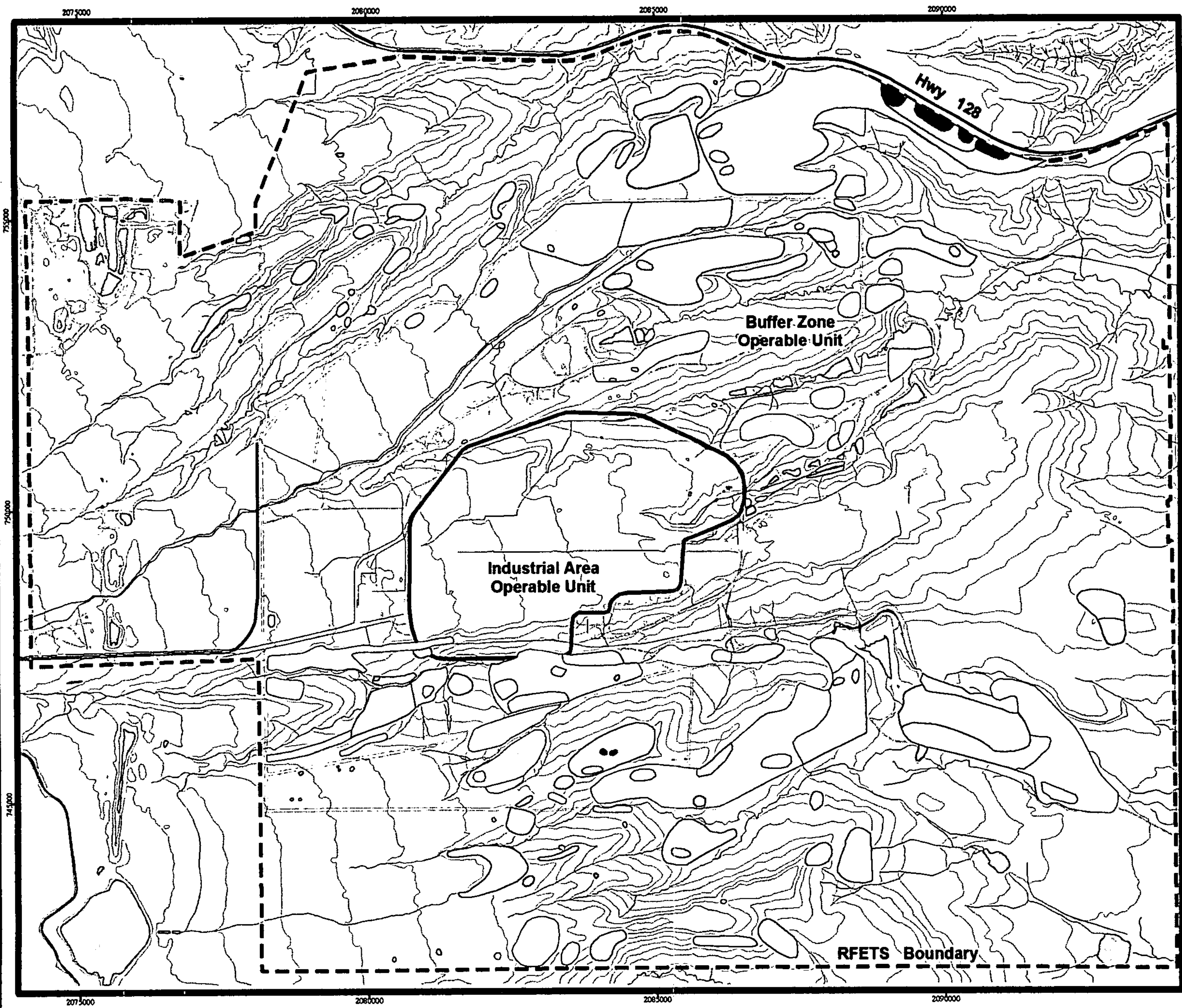

Figure 23
Musk Thistle
(Carduus nutans)
2001 Distribution

Standard Map Features

- High density area
- Medium density area
- Low density area
- Scattered density area
- Lake or pond
- Stream, ditch, or other drainage feature
- Dirt road
- Gravel road
- Topographic contour (20-foot)
- RFETS boundary

Source:
2001 Annual Vegetation Report for the RFETS, Kaiser-Hill Company, L.L.C. May 2002

N
W E
S

500 0 500 1000 1500 2000 2500
Scale in Feet

Scale = 1 : 30,000
1 inch represents 2,500 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: Date: February 15, 2005

URS

Prepared for:

KAISER•HILL

117

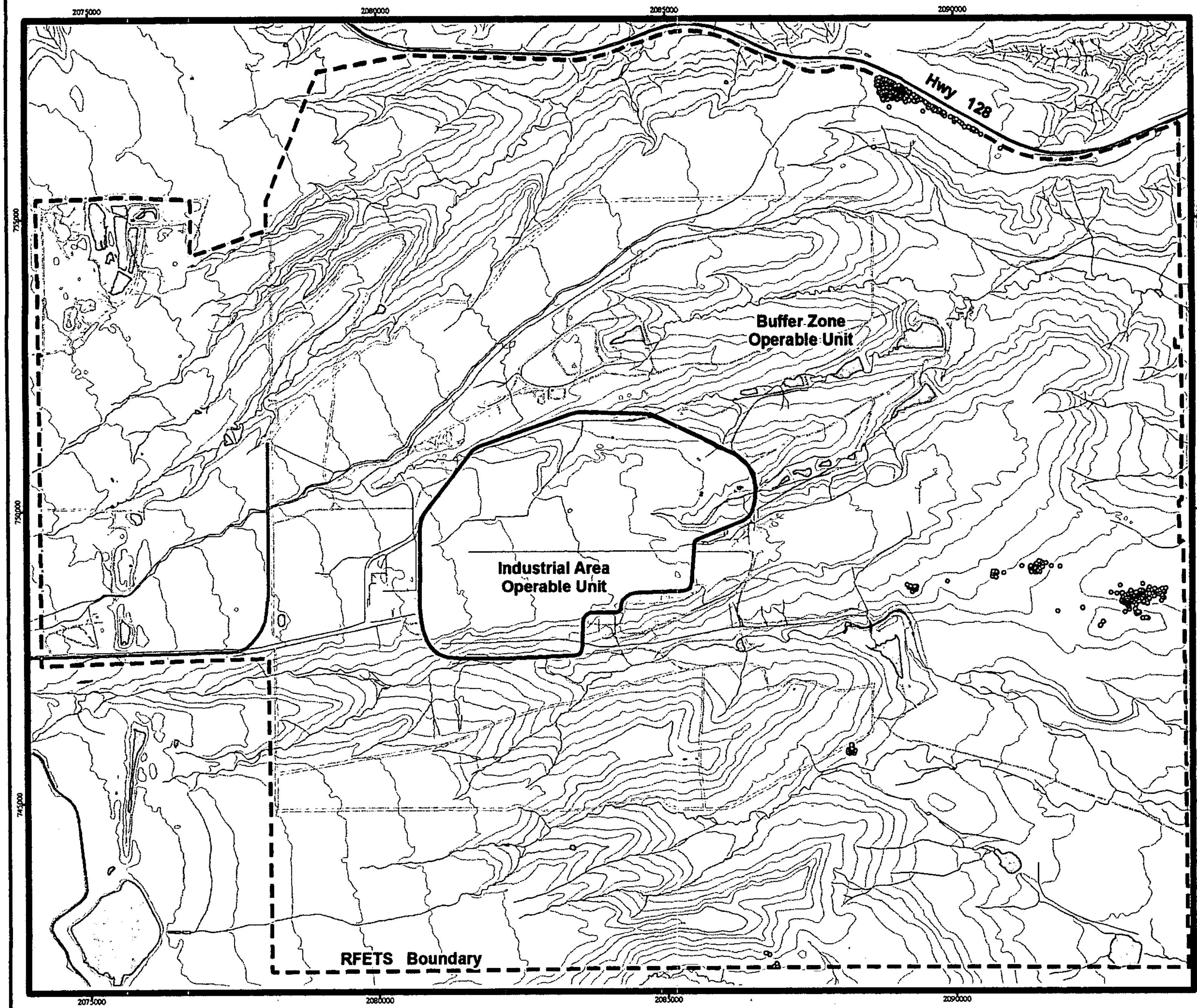

Figure 24

Potential Prairie Dog Habitat

Standard Map Features

- Prarie dog hole
- Lake or pond
- Stream, ditch, or other drainage feature
- Dirt road
- Gravel road
- Topographic contour (20-foot)
- RFETS boundary

Source:
K-H, 2003. 2002 Annual Ecology Report for the Rocky Flats Environmental Technology Site. Prepared by Kaiser-Hill Company, LLC, Rocky Flats Environmental Technology Site, Golden, CO. Prepared for the U.S. Department of Energy, Rocky Flats Field Office, Golden, CO.

DRAFT

N
W E
S

500 0 500 1000 1500 2000
Scale in Feet
Scale = 1 : 30,000
1 inch represents 2,500 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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Rocky Flats Environmental Technology Site

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Prepared for:

KAISER•HILL

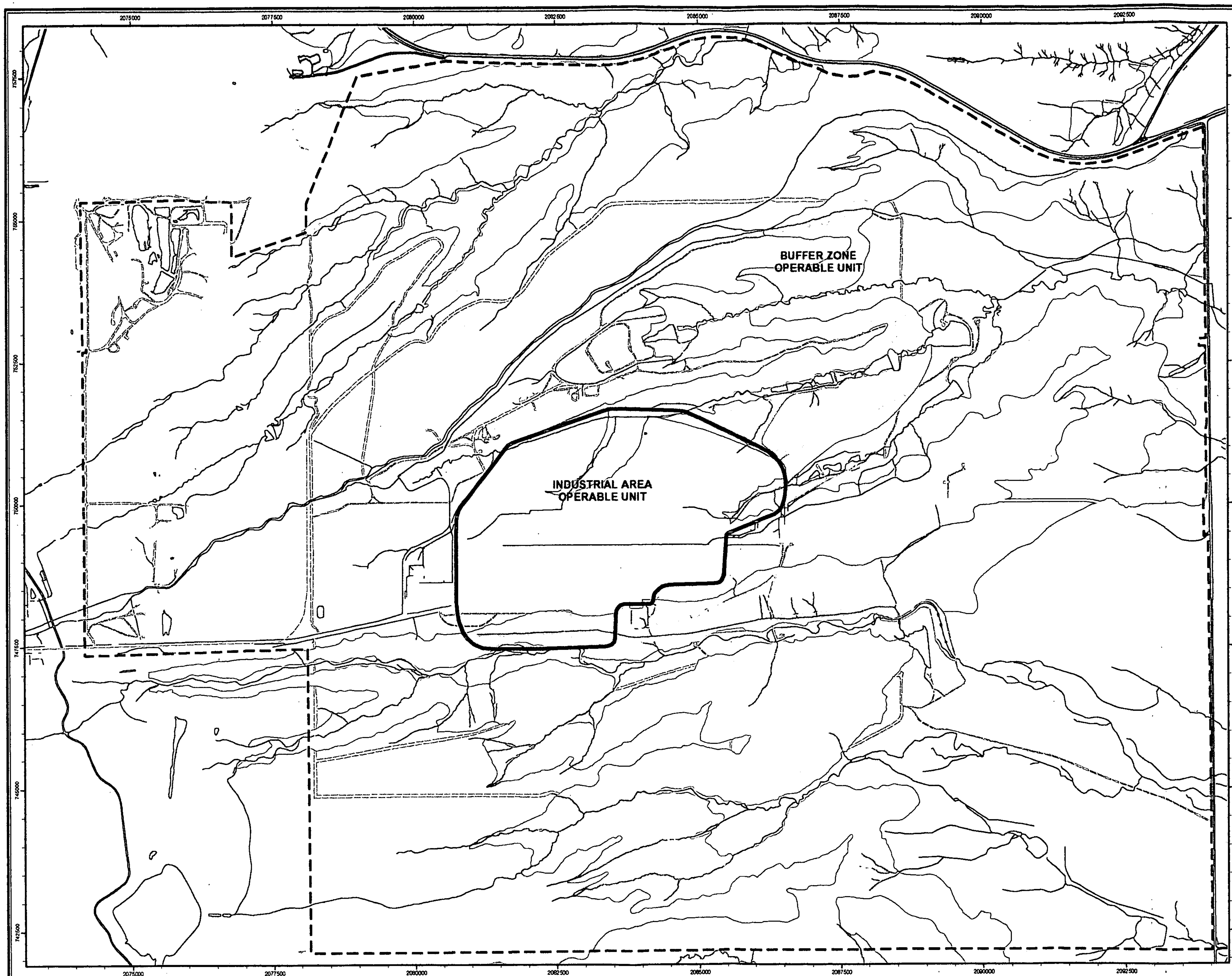

Figure 6
Landslide & High Erosion Areas

LEGEND

Gravel roads

Areas of landslides and high erosion. Contaminated sites within these areas must be evaluated per Risk Screen 2 of Figure 3.

Source: RFCA Attachment 5
May 28, 2003

Standard Map Features

RFETS Boundary

Lakes and ponds

Streams, ditches, or other drainage features

Paved roads

Dirt roads

Industrial Area Operable Unit Boundary

N

625 0 625 1,250 1,875 2,500 Feet

State Plane Coordinate Projection
Colorado Central Zone (3476)
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared By:

CH2MHILL

GIS DEPT. (303) 966-7707

Prepared For:

KAISER•HILL
COMPANY

DATE: 1/25/2005

99

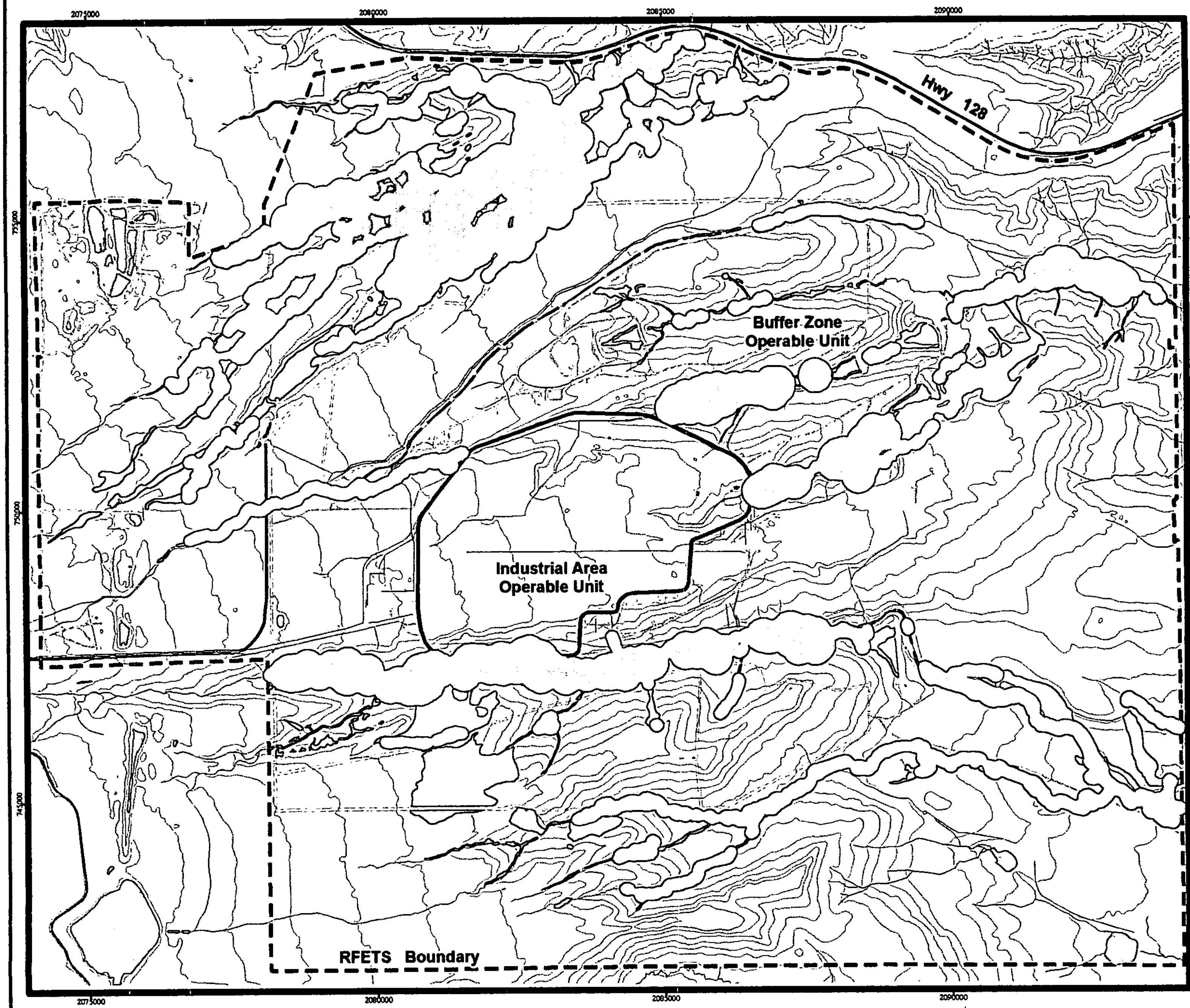

Figure 26

Preble's Meadow Jumping Mouse Habitat

Standard Map Features

- Protection area
- Contiguous wetlands
- Undefined PMJM area
- Lake or pond
- Stream, ditch, or other drainage feature
- Dirt road
- Gravel road
- Topographic contour (20-foot)
- RFETS boundary

Source:
DOE, 2004, Programmatic Biological Assessment for Department of Energy Activities at the Rocky Flats Environmental Site, Part II, Revision 7. U.S. Department of Energy, Rocky Flats Field Office, Golden, CO. April 2004.

DRAFT

N W E S

500 0 500 1000 1500 2000
Scale in Feet

Scale = 1 : 30,000
1 inch represents 2,500 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: URS
Date: January 20, 2005

Prepared for: KAISER-HILL